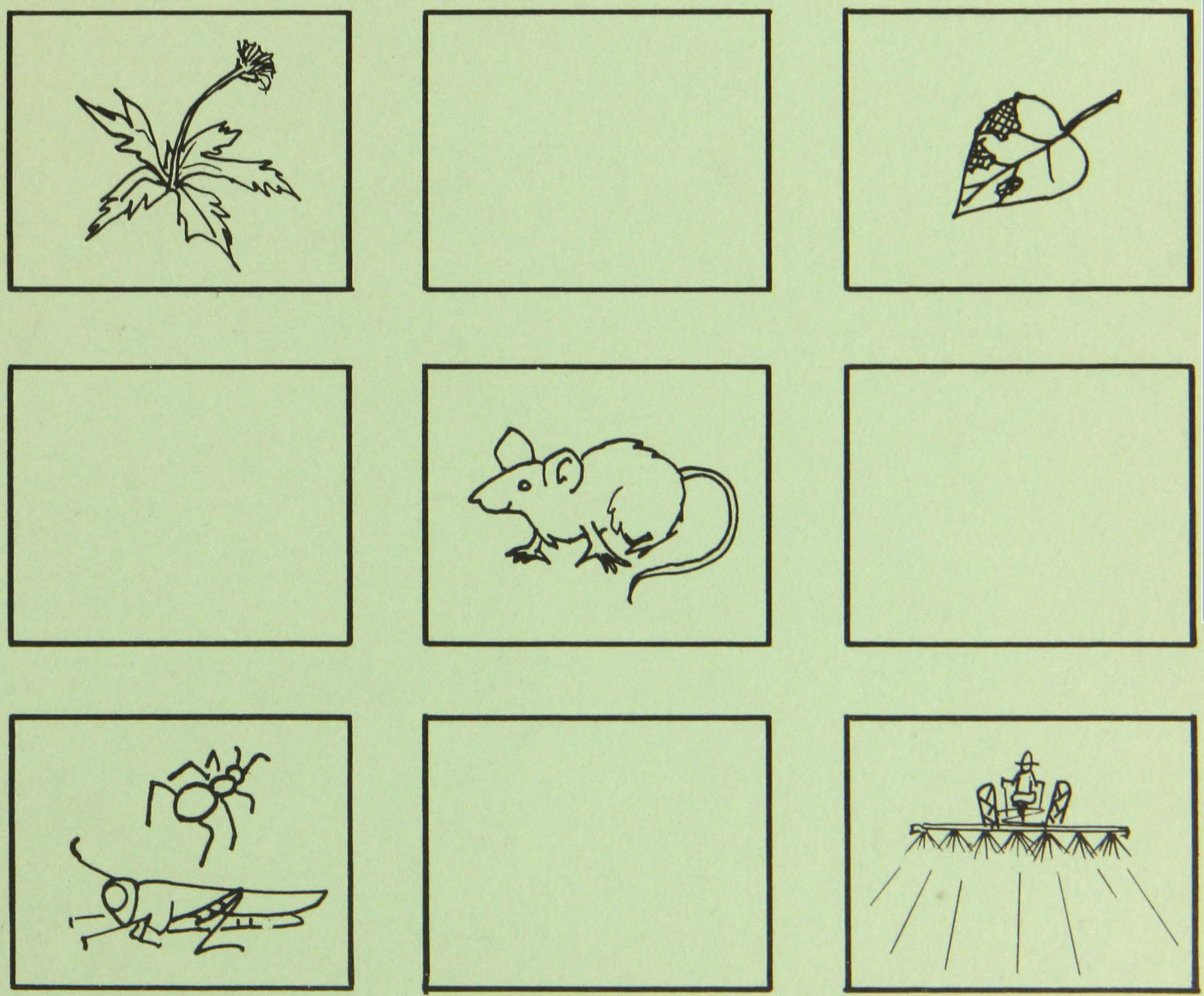
Extension Bulletin 428—Revised-1978

Pesticide Applicator's Manual

AGRICULTURAL EXTENSION SERVICE
UNIVERSITY OF MINNESOTA

Prepared by extension specialists at the University of Minnesota



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Pesticide Applicator's Manual

Introduction

Everyone who uses pesticides has the responsibility to use them safely. Some pesticide uses are classified by federal and state regulatory agencies as restricted. This means that some uses of pesticides may present particular hazards to people, crops, animals, or the environment, making it necessary to require special competence of the people who use them.

This publication contains the information you will need to meet the requirements for certification to use restricted pesticides in Minnesota. More detailed information about specific pests and pesticides and current recommendations for weed, disease, insect, and rodent control is available at your local county extension office.

State and federal regulations require that to be certified you should be able to:

1. Recognize the common pests (weeds, plant diseases, insects, rodents) in your area and the damage caused by them.
2. Read and understand the labels on pesticide containers.
3. Apply pesticides in accordance with label directions and warnings.
4. Recognize environmental situations that must be considered during application to avoid contamination.
5. Recognize poisoning symptoms and procedures to follow in case of a pesticide accident.

You should also be familiar with laws, rules, and regulations dealing with the pesticides you use.

Pest Control Principles

The most important step in preventing or controlling a pest problem, whether it involves weeds, insects, plant diseases, rodents, nematodes, mites, pest birds, etc., is to identify the problem(s) correctly.

You probably know some of the most common or troublesome pests in your area. But at times unfamiliar problems appear. It is essential that you properly identify a pest and determine the economic significance of a pest problem before you undertake control measures.

Several kinds of assistance are available for helping you identify pests. There are publications containing descriptions and pictures as well as various keys you might learn to use. The best thing to do if you encounter an unfamiliar or suspected pest is to contact your local county or area extension agent, county agricultural inspector, or vocational agriculture teacher. If these people cannot identify the pest, they can contact the appropriate department of the University of Minnesota.

WEEDS

Characteristics

A weed is most simply defined as a plant out of place. Weeds are responsible for huge expenditures of energy and money every year. In fact, estimates of annual costs range above $5 billion.

Weeds are a problem because their presence can mean:

- reduced crop yields.
- less efficient land use.
- reduced product quality.
- diminished enjoyment of outdoor recreation.
- spoiling of the beauty of turf and ornamental plants.

Identification of Weeds

Weed Names. Most weeds have common names like cocklebur or crabgrass. The trouble with common names is that people in different places often use different common names for the same plant. Labels on herbicide containers and in the supporting literature generally use standardized common names. You need to be able to identify a weed by a common name so you can choose the proper herbicide and find control information in supporting publications.

Life cycles. Before you can control weeds, you need to know something about how they grow. One way to identify plants is on the basis of the length of their life cycles.

Plants with a 1-year life cycle are **annuals**. Such plants grow from seed, mature, and produce seed for the next generation in 1 year or less. These plants, whether they are grass-like (crabgrass and foxtail) or broadleaved (pigweed and cocklebur), are easy to control when young. Control measures should be used early in the growing season, not only to destroy the plants of that generation, but to prevent seed formation for the next.

Summer annuals are plants that result from seeds that germinate in the spring, grow, mature, produce seed, and die before winter each year. Examples include crabgrass, foxtail, cocklebur, pigweed, and lambsquarters.

Winter annuals are plants that grow from seeds that germinate in the fall, grow, mature, produce seed, and die before summer each year. Examples include cheat, henbit, and annual bluegrass.

Biennials, plants with a 2-year life cycle, require 2 years to complete their life cycles. These plants grow from seed that germinates in the spring. They develop heavy roots and compact rosettes or clusters of leaves the first summer. Biennials remain dormant through the winter; in the second summer they mature, produce seed, and die before winter. Examples include mullen, burdock, and bull thistle.

Plants that live more than 2 years and may live indefinitely are **perennials**. These plants may grow from seed, but many produce tubers, bulbs, rhizomes, and stolons. The aboveground portions of these plants may die back each winter, but the plants develop new aboveground parts each spring. Examples include Johnsongrass, field bindweed, dandelion, and plantain.

Perennial plants can be further grouped as:

creeping perennials, which produce seeds but also produce rhizomes (belowground stems) and stolons (aboveground stems). Examples include quackgrass, Canada thistle, and field bindweed.

simple perennials, which produce seeds each year as their normal means of reproduction (in some instances, root pieces may produce new plants following mechanical injury during cultivation). Examples include dandelions and plantain.

bulbous perennials, which produce seeds and bulbs than can form aboveground bulbs (wild garlic) or belowground bulbs (wild onions).

Principles of Weed Control

Here are some common terms you should know before planning weed control.

Selective herbicide: an herbicide that is more toxic to some kinds of plants than to others. The degree of selectivity is affected by plant age, rate of growth, plant form, and physiological differences.

Nonselective herbicide: an herbicide that is toxic to all plants. Some nonselective herbicides can be made selective to some plants by varying the dosage, by directing the spray to a specific site, or by choosing spray additives such as wetting agents. Selective herbicides can be made nonselective by manipulating the same factors.

Contact herbicide: an herbicide that is directly toxic to living cells upon contact. These herbicides destroy only the aboveground parts of plants and are effective against many annual weeds.

Translocated herbicide: an herbicide that can be absorbed by leaves and stems or roots and moved throughout the plant. Root absorption and translocation occur in the water-conducting tissues (xylem). Leaf or stem absorption and translocation occur primarily in the food-conducting tissues (phloem).

"Soil sterilant" herbicide: a nonselective herbicide that kills all plants and prevents reestablishment of weeds for a relatively long time.

The following terms concern application times for herbicides.

Preemergence: applied to the soil before crops and weeds emerge. This term may also refer to applications after crops emerge or are established but before weeds emerge.

Preplant: applied to the soil before the crop is planted.

Postemergence: applied after the crop and weeds emerge; may also refer to applications after weeds emerge but before crops emerge.

The terms below describe application methods.

Broadcast spray: uniform application to an entire, specific area.

Band spray: application to a strip over each crop row.

Over-the-top spray: application over the top of the growing crop and weeds.

Directed spray: application of chemical by aiming the spray nozzle at the base of the crop plant to avoid crop contact.

Spot treatment: application to destroy plants in a small area.

Soil incorporation: application of chemicals to the soil, followed by mechanical mixing of the herbicide with soil.

Factors Affecting Herbicide Activity

Soil Factors—Organic matter in soils limits herbicide activity. Soils with high organic matter content require higher rates of herbicides for effective weed control than do soils with low content. Most herbicide labels include charts showing the rates to be used on soils with varying levels of organic matter.

Soil texture also affects herbicide activity. Soils with finely divided particles (silts and clays) provide more surface area than coarser soils (sands). High herbicide rates are generally used on clay or silt and low rates on sandy soils.

Soil acidity—The activity of some herbicides is influenced by soil acidity. Chemicals such as atrazine and metribuzin are more active in soils that are less acid (higher pH).

Environmental Factors—Soil moisture and rainfall affect herbicide activity and disappearance from soil and plants. Good soil moisture conditions allow the highest levels of herbicide activity. Dry conditions may cause the herbicide to evaporate, whereas wet conditions may keep the herbicide from contacting soil particles. Warm, moist soil may cause herbicides to disappear through microbial activity and chemical reactions. Rainfall causes soluble herbicides to leach downward into the soil profile, a process that may be desirable with relatively insoluble herbicides and undesirable with more soluble herbicides (due to possible crop injury). Heavy rainfall may result in poor weed control or possible crop injury, depending on the relative solubility of the herbicide.

Rainfall is needed to carry surface-applied preemergence herbicides down into the soil where weed seeds are germinating. Soil moisture is needed for weed seed germination so seeds can absorb lethal amounts of herbicide. Rain during or soon after postemergence applications may wash herbicides from leaf surfaces, resulting in poor weed control.

Humidity affects herbicide penetration and absorption. High relative humidity indicates favorable soil moisture conditions for rapid plant growth, a time when plants are very susceptible to herbicide effects.

Dew on the weeds or crop at the time of herbicide application or formed on the plant shortly after application may increase the activity of some herbicides but decrease the activity of others, depending on how quickly the chemical is absorbed by plants and how it kills plants.

Temperature affects the rate of plant growth and plant susceptibility to herbicide effects. In addition, some herbicides will evaporate quickly at high temperatures.

Light may break down some herbicides if they are left on the soil surface for extended periods.

Other Factors—Plant species and varieties — Perennial plants are generally more difficult to kill than annual plants. Repeated applications may be required to destroy infestations of perennial weeds. Translocated herbicides are more effective than contact herbicides because they move into all parts of the plant, whereas contact herbicides kill only aboveground plant parts.

One weed may respond differently to different herbicides, and slightly different weeds within the same species may respond differently to the same herbicide.

To minimize herbicide residues in the soil, employ these practices:

- apply the lowest practical rate of herbicide.
- apply the herbicide uniformly, avoiding double coverage. Equip sprayer nozzles with check valves and quick-closing cutoff valves for turns. Shut off the applicator when turning.

- select crop sequences that are tolerant to the herbicide used on the previous crop.
- rotate herbicides when the same crop is grown continuously, and rotate herbicides on all crops grown in a rotation.

INSECTS ATTACKING CROPS

A large number of different insects affect crop plants in a variety of ways. They may cause damage by chewing off foliage; by tunneling or boring into stems, stalks, and branches; by pruning off and tunneling into roots; by sucking the sap from leaves, stems, roots, fruits, and flowers; and by transmitting plant diseases.

These activities result in killed, weakened, and disfigured plants which in turn cause reduced yields, lowered quality, and unmarketable, unsightly plants or their products. Even after harvest, insects continue their damage in stored or processed commodities.

Insects are very adaptable animals with high reproductive capacities. Since they are arthropods, they have external skeletons like suits of armor and three pairs of jointed legs. Many species of insects can fly, and some of these are capable of migrating long distances.

Insects grow through a process of change called **metamorphosis**. Some, like grasshoppers and plant bugs, develop gradually. Their eggs hatch into nymphs that shed their skins, or **molt**, between growth stages, called **instars**, before becoming adults. Others, like beetles, armyworms, and cutworms, change more completely. Their eggs hatch to produce **larvae**, which grow through instars to a **pupal** stage, in which the adult is formed. Plants can be damaged by the immature stages of some insects, by the adults of others, and by both in still others.

Effective insect control is often based on knowledge of the pests' growth habits.

Insects are subjected to limiting factors, or hazards, during their lives. These forces may hold the numbers of a crop pest below the economic level. When the effects of these limiting factors are reduced through natural events, farming methods, or other human activities, the numbers of these pests will rise to levels at which damage may occur. The challenge lies in our ability to manage crops in such a way that the injury caused by insects is held to a minimum and to recognize when more direct action, such as pesticide applications, is necessary.

Principles of Control

Controlling insect pests or the damage they do can be considered from two standpoints. One is a short term, direct sort of action; the other is a long range damage prevention program. Either type may be needed, depending on the circumstances. As needed information becomes available, we should strive toward total crop management systems that approach the ideal of damage prevention. Whether it is short or long term, however, an effective crop insect control program should follow some logical sequence.

Steps in Crop Insect Control

Detection. Too often, controls are attempted only after the damage has been done. It is important to develop and maintain a survey or detection plan to provide early warning about pest populations. Some of this warning is made available by the Cooperative Economic Insect Survey operation in most states. Pest management projects, scouting programs, and individual grower vigilance are other techniques.

Identification and Diagnosis. Most growers learn to recognize the most important insect pests associated with their crops, but, as mentioned previously, unfamiliar or new pests may appear occasionally. Identification aids, publications, and pictures can be helpful, but the best course of action is to call on competent consultants (see "Pest Control Principles," page 3).

Sometimes insect infestations show up as damaged plants without any signs of the responsible insect itself. In these cases, a diagnosis must be made to determine whether the symptoms are due to insects or to some other cause.

Economic Evaluation. Determining the economic significance of an infestation (in terms of yield and crop quality) is essential. It can be done by considering the numbers and stage of development of the pest, the stage of growth and economic potential of the crop, the numbers of parasites and predators, the weather conditions, and all the other many factors that might affect the impact of the pest insect on the crop. In many cases, **economic thresholds** have been determined. In such instances, fields should be surveyed properly by the grower or the scout to accurately gauge the insect population. This determination is one of the important pieces of information necessary for making decisions involving economic thresholds.

Knowledge About Life Habits of Pests. When an insect pest is new to an area, it may be necessary to conduct research or to make observations to learn about its habits so control methods can be developed. This process may range all the way from making a few observations to a long range, complex research project.

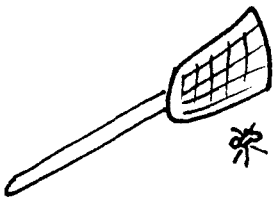
Development and Improvement of Control Methods. Obtaining accurate information about the habits and economic importance of a pest will lead to the development and selection of the best combination of practices to minimize damage. Continued experience will lead to a refining of the techniques that work best for specific locations and situations. This process also may be very simple or highly complicated and may extend over many years.

Prescriptions or Recommendations. Ultimately, a decision must be made based on all available information. It may be a recommendation by a professional advisor or consultant to a farmer, a legal order or prescription by a government official, or simply a decision made by a grower after making certain field observations. The decision may involve a long-range crop management plan or it may simply involve the selection of a certain rate of a pesticide.

Implementation. The success or failure of a pest control or management program depends on its execution. Crop rotations must be followed. Certain tillage practices must be carried out on time. The proper variety must be planted. The right pesticide must be applied at the right time at the right rate in the right place. If any part of a total management program is neglected, the whole job may fail.

Evaluation, Recording, and Improvement. Most human effort can be improved. To bring about changes in a pest management program, it is necessary to measure the effectiveness of individual practices. This can be done, for example, by making careful observations and taking notes, by leaving check strips, or by determining yields or quality improvement.

It is also important to keep accurate records of dates, weather conditions, and similar information related to pest control practices, especially pesticide application. Such records will be valuable not only for possible legal purposes but for use as an action guide should the same problem recur.



Methods of Crop Insect Control

A great deal of natural control goes on in most pest populations. This natural control results from the hazards or limiting factors referred to above. The controls described below include only artificial or man-manipulated measures.

Cultural Control. These methods relate to crop rotations, tillage practices, planting dates, field locations, drainage, fertility, and all other crop culture procedures that might adversely affect insect pests, either directly or indirectly.

Using insect-resistant or tolerant genetic lines of crops might also be considered a cultural control method, although it usually is considered a biological method.

Biological Control. Predators, parasites, or disease organisms can be released into a pest population to help stabilize it. The release of sterile males and the use of pheromones, insect growth regulators, and sterilants are other control methods that can be considered biological methods, even though they sometimes involve the use of chemicals.

Mechanical-Physical Control. The use of traps, barriers, light, sound, heat, cold, nuclear radiation, and electrocution are some physical control methods. Such methods have limited application in crop insect control, except where storage pests are involved.

Legal Control. Quarantines, inspections, embargoes, compulsory crop or product destruction, and similar actions taken under the provisions of federal, state, or local laws and regulations are examples of legal control measures.

Chemical Control. Chemicals can be used to kill, repel, attract, or sterilize insects or to interfere with their normal behavior. The most widely known chemicals used in crop insect control are insecticides. Little use is made of sterilants, repellents, or attractants at this time.

Integrated Control. This method involves the use of a combination of practices that fit into an effective program of pest reduction. An integrated program usually involves the selection of planting and harvest dates and resistant varieties, the use of pest-specific insecticides, and the encouragement or distribution of biological control agents. It usually includes elements of pest management, so insecticides are applied only when numbers of pests observed reach economic thresholds.

INSECTS AFFECTING LIVESTOCK

Many of the principles discussed under crop insects apply to the control of livestock pests as well.

Insects and related arthropods in this group constitute a wide variety of pests. The more important ones include the biting and nonbiting flies, mosquitoes, lice, and grubs. They cause damage by sucking blood, invading tissues, carrying diseases, and causing annoyance or irritation.

Control measures include sanitation, screening, and the application of chemicals to the host animals or to the breeding sites.

PLANT DISEASES

Characteristics

A plant disease is any condition in which a plant is different in some way from a normal (healthy) plant in either structure or function. A diseased plant may be shorter or have more branches or fewer leaves than normal, making it different in structure. It may wilt and die prematurely, or it may not produce flowers or fruit, making it different in function.

A plant disease has four main features. Disease is a **process**; it does not occur instantly as does an injury. It is **physiological**, affecting all or some of the functions of the plant. It is **abnormal** to the plant. It is **harmful** in some way, even though the harm may not always be immediately detectable.

Three ingredients must be present for a disease to develop:

- a susceptible host plant.
- a disease-producing agent (the pathogen), which may be living or nonliving.
- an environment favorable to disease development.

Causes of Plant Diseases

The definition of plant disease is very broad and encompasses all possible causal agents, including insects, as long as the four criteria cited above are satisfied. For example, insects that produce galls or plant parts are true causal agents of disease. Insects, however, are generally omitted from the area of plant disease and covered in the field of entomology.

Plant diseases are divided into two broad groups based on their cause.

Nonparasitic diseases are caused by factors such as nutrient deficiency, extreme cold or heat, toxic chemicals (air pollutants, weed killers, too much fertilizer), mechanical damage, lack of water, adverse genetic changes, and many others. These diseases cannot be passed from one plant to another. Their control depends solely on correcting the condition (usually something in the environment) that causes the disease.

Parasitic diseases are caused by living organisms that live and feed on plants. The most common causes of parasitic diseases are fungi, bacteria, viruses, and nematodes. A few seed-producing plants, such as the mistletoes, also can cause plant diseases.

Fungi are plants that lack the green coloring (chlorophyll) found in seed-producing plants, so they cannot make their own food. There are more than 100,000 kinds of fungi of many types and sizes. Not all are harmful, and many are helpful to man. Most are microscopic, but some, like the mushrooms, are quite large.

Most fungi reproduce by spores, which vary greatly in size and shape. Some fungi produce more than one kind of spore, and a few fungi have no known spore stage.

Bacteria are very small, one-celled plants that reproduce simply by dividing in half. Each half becomes a fully developed bacterium. This type of reproduction may lead to rapid buildup of a population under ideal conditions. Some bacteria, for example, can divide every 30 minutes. In 24 hours, a single cell could produce 281,474,956,710,656 offspring.

Viruses are so small they cannot be seen with the ordinary microscope. They are generally found and studied by their effects on selected "indicator" plants. Many viruses that cause plant disease are carried from one plant to another by insects, usually aphids or leafhoppers. Viruses cause serious problems in plants that are propagated by bulbs, roots, and cuttings because the virus is easily carried along in the propagating material. Some viruses can be easily transmitted by rubbing the leaves of healthy plants with juice from diseased plants. A few viruses are transmitted in pollen. The big vein of lettuce virus is transmitted by a soil-borne fungus, and a few viruses are transmitted by nematodes.

Nematodes (or nemas) are small, usually microscopic, worms that reproduce by eggs. Their rate of reproduction depends largely on soil temperature, so nematodes are usually more of a problem in warmer areas. Most nematodes feed on the roots and lower stems of plants, but a few attack the leaves and flowers. They usually do not kill plants, but they do reduce growth and affect plant health.

All nematodes on plants have a hollow spear that they use for puncturing plant cells and feeding on the cell's contents. Nematodes may develop and feed inside or outside a plant. A complete life cycle involves an egg, four larval stages, and an adult. The larvae usually look like the adults but are smaller. The females of some, such as root knot and cyst nematodes, become fixed in the plant tissue and their bodies become swollen and rounded. The root knot nema deposits its eggs in a mass outside its body. The cyst nema keeps part of its eggs inside its body, where they may survive for many years.

Development of Plant Diseases

Parasitic diseases depend on the life cycle of the parasite, which is greatly influenced by environmental conditions, especially temperature and moisture. These conditions not only influence the activities of the disease organism, but they affect the ease with which a plant becomes diseased and the way the disease develops.

The life cycle of a pathogen begins with the arrival of some portion (fungus spore, nematode egg, bacterial cell, virus particle) at a part of the plant where infection can occur. This step is called **inoculation**. If environmental conditions are favorable, the parasite will begin to develop. This stage is called **incubation**. If the parasite can get into the plant, the stage called **infection** starts. The plant is diseased when it responds to the invasion of the pathogen in some way.

A diseased plant, like a sick person, generally shows some symptoms. In fact, a disease often gets its name from the plant's symptoms. The three general types of symptoms are:

- overdevelopment of tissue (galls, swellings, leaf curls).
- underdevelopment of tissue (stunting, lack of chlorophyll, incomplete development of organs).
- death of tissue (blights, leaf spots, wilting, cankers).

Identifying Plant Diseases

Because several different diseases may cause the same symptoms, you can't always identify a plant disease by looking at symptoms alone. Looking at the signs, the structures of the pest, is a better way of identifying a disease. Signs include such things as fungus spores, nematodes or their eggs, and bacterial ooze. Usually you need a microscope or magnifying lens to see the signs. You need more training to find and identify signs than you need to observe symptoms.

Principles of Control

To control plant diseases, you must first consider the three factors involved in the disease: the host plant, the pathogen, and the environment. Then you must consider the cost.

Not all control measures work for all kinds of pathogens. Some hosts will not tolerate some controls, and the environment limits the kind of control measure that can be used and the time it can be used. One categorization of plant disease control methods includes:

- avoidance of the pathogen.
- exclusion of the pathogen.
- eradication of the pathogen (and its vectors).
- protection of the host from the pathogen.

Avoidance and protection are both aimed at keeping the pathogen away from the plant. Exclusion and eradication are directed at the pathogen itself, either by killing it or by preventing it from reaching a host.

Examples of Control

Avoidance: by choosing planting sites and dates of planting, by using resistant varieties, and by employing sanitation, crop rotation, and primordium tip-culture techniques.

Exclusion: by following quarantine regulations supported by adequate inspections to prevent the introduction of pathogens on or in plants or equipment into areas where they do not already exist, and by certifying seed and nursery stock.

Eradication: by roguing (removing) infected plants or plant parts, by treating soil or plant parts with heat, by fallowing field, and by using pesticides, for example, in controlling nematodes.

Protection: by using chemical applications, by using proper storage or curing methods for plants and plant products and proper nutritional programs to ensure maximum plant vigor, by using water management, and by employing biological methods such as the use of hyperparasites, antagonistic microorganisms, or cross-protection techniques for viruses.

Avoidance and exclusion are by far the best methods for controlling plant diseases. Once a plant is infected, it is usually too late to prevent its death or serious reductions in crop yields. Where only part of a crop is diseased, chemical control may prevent further spread. Always weigh the cost carefully before making treatment decisions.

VERTEBRATE PESTS

Characteristics

All vertebrate animals have a jointed spinal column (vertebrae). These "higher" animals include fish, snakes, turtles, alligators, lizards, frogs, toads, salamanders, birds, and mammals. Because there is a closer relationship between humans and the other vertebrate species, the general public is more reluctant to kill members of this group than the "lower" life forms like plants and insects. But what may be a pest under some circumstances may be a highly desirable form under others.

Damage Recognition

Fish. People have induced most fish problems themselves by attempting to put various species in places where they would not have occurred normally. Some kinds of fish are considered undesirable simply because they are not useful for sport or for food, or because they are harmful to more desirable species. Fish that serve as intermediate hosts for some parasites of humans can cause health hazards, however.

Reptiles and Amphibians. Reptiles (snakes, lizards, turtles, and alligators) and amphibians (frogs, toads, and salamanders) can cause local problems. The reaction against these animals is more psychological than economic, but poisonous snakes and the presence of snakes and turtles in fish hatcheries or waterfowl production areas can cause real problems.

Birds. Damage caused by birds can be varied. It includes structural damage by woodpeckers; killing of fish, livestock, poultry, or game species; and destruction of fruit, nut, grain, timber, and vegetable crops. Birds also can present hazards to animal and human health, as they can be hosts for disease organisms. Peck marks, location of damage, tracks,

feathers, droppings, and evidence indicating that items have been carried away form the bases for determining bird depredation.

Mammals. Damage by mammals is as varied as that done by birds. Livestock and human health problems are even more important when mammals are involved. Diseases that mammals transmit to humans include rabies, plague, typhus, food poisoning, leptospirosis, and tularemia. Killing of other animals by mammals is costly, particularly when large livestock is involved. Mammals also do significant damage to fruit, vegetable, nut, grain, range, and tree crops. Their interference with water-retaining structures and the consequent flooding of areas can be of extreme economic concern. They damage such things as lawns, clothing, furniture, and buildings by gnawing and burrowing.

How do you tell which kind of mammal was responsible for a particular type of damage? You can eliminate some suspects if you know which animals are found in your part of the country, what kinds of places they live in, and what their habits are. Animal signs (tracks, droppings, toothmarks, diggings, burrows, hair, and scent) plus the type of damage you find will provide further clues.

Principles of Control

To solve vertebrate pest problems, an applicator must:

- recognize damage patterns and the species of animal responsible.
- know the physical characteristics and life habits of most animal species present in a given situation.
- be aware of the control measures available that would be effective, selective, humane, and cause the least possible environmental damage.
- know the local, state, and federal regulations that apply to the situation.
- realistically evaluate the risks and benefits of the available control measures.

The Pesticide Label

The pesticide label is the most important source of information about any specific pesticide you're planning to use. The label describes products that represent the culmination of many years of research and development and millions of investment dollars.

INFORMATION FOUND ON PESTICIDE LABELS

Name of the Pesticide

Pesticides go by several names, but in general there are brand names, trade names, approved common names, and chemical names.

Brand Names. A brand is a name used by a company with a series, or line, of different products. Therefore, a brand name like "Ortho" or "Diamond" does not indicate the nature of a pesticide. It is also possible to have several different brands of the same pesticide.

Trade Name. A trade Name is a registered name used by a company for a specific pesticide formulation. Sevin® 80W and Sevimol® -4 are two different trade-named pesticides that contain the same active ingredient, carbaryl, formulated by the same company. Cygon® 267 and DeFend® are two different trade names for pesticides containing dimethoate that are formulated by two different manufacturers.

Approved Common Names. An approved common name is given to the active ingredient of a pesticide that has been formally adopted by official agencies and societies. AAtrex® 80W contains atrazine as its active ingredient, and atrazine is the common approved name. Metribuzin is the common approved name for the active ingredient in Sencor® and Lexone®.

Chemical Names. These names denote the chemical constituents and structure of the active ingredient. For example, 1 naphthyl-N-methyl-carbamate is the chemical name for carbaryl, which is the common approved name for that ingredient in Sevin®.

The Ingredient Statement

The ingredient statement indicates the percentage of active ingredient in a formulated pesticide. There may be a statement of the weight per gallon of active ingredient in liquid formulations. In some pesticides the pesticidally active component is an acid, in which case the formulated product will have the percentage or pounds of acid equivalent per gallon. It may also have another percentage of active ingredient. In this case, you should use the acid equivalent statement to determine the contents of the formulation. Here are two examples.

A 50 percent wettable powder contains 50 percent or half the total net weight of active ingredient, so a 10-pound bag of Brand X 50 percent will contain 5 pounds of the pesticidally active chemical part of the formulation. The rest may be listed on the label as inert ingredients (diluent, wetting agents, stickers, etc.).

SAMPLE LABEL: FRONT

RESTRICTED USE PESTICIDE
For retail sale to any application only by certified applicators or persons under their direct supervision.

Contents 5 Gallons

Minny® Brand
Murd-O-Weed® 4E
Abadabra Herbicide

An emulsifiable selective weed control chemical for the control of grassy weeds in corn, soybeans, and kumquats.

ACTIVE INGREDIENTS 27.2%
(abadabra) 1-10 cyclo, cyclo, metamethyl, abratite aspic salt)
(Total abadabra acid equivalent ..... 22.8%)

INERT INGREDIENTS 72.8%

Contains 2 lb. abadabra acid equivalent per gallon
U.S. Patents 1234567 and 12345678

CAUTION: KEEP OUT OF THE REACH OF CHILDREN
Read complete label before use

MINNY CHEMICAL COMPANY, Inc., Weedtown, Minnesota
EPA Reg. No. 4242XX
EPA Est. No. IIIX22

*Registered Trademark, Minny Chemical Co.

SAMPLE LABELS: REAR OR SIDE PANELS

MURD-O-WEED 4E is effective for the control of most common grassy weeds, except fuzzy zipgrass, in corn, soybeans, and kumquats. It should be applied as a broadcast spray before planting and incorporated into the soil by disking four times in each direction.

MURD-O-WEED may be applied by aerial or ground equipment.

USE ONLY ACCORDING TO DIRECTIONS ON THIS LABEL.

DO NOT FREEZE.

WARRANTY

Minny Chemical Company warrants that this product conforms to the chemical description given on this label. It is suited for the purpose for which sold when used according to directions. The buyer agrees to assume all risks in the case of damage from the use of this product.

DIRECTIONS FOR USE

How Much to Use

Apply 1 to 2 quarts MURD-O-WEED 4E in sufficient water to uniformly cover 1 acre. Use lower rate for sandy soils and higher rate for clay or organic soils. Check your local agricultural extension service for additional information on rates for your soil conditions.

When to Apply

MURD-O-WEED 4E should be applied at least 1 week before planting corn or soybeans and at least 3 days before planting kumquats.

USE PRECAUTIONS

Do not graze livestock on treated fields. Do not allow drift to contaminate adjacent crops, pastures, rivers, or other waterways.

CAUTION!!

May be harmful if swallowed, will cause irritation to eyes and skin. Avoid contact. Do not breathe spray mist.

Do not store near food, feed, fertilizers, or seed.

Rinse and drain containers thoroughly after use. Puncture and crush empty containers and dispose of them in a land fill disposal site.

Rinse sprayer thoroughly after use and dispose of wastes by burying them in a pit away from crop and livestock areas so water supplies are not contaminated.

LOT 11111

A liquid concentrate of Brand Y contains 47.3 percent of active ingredient. The acid equivalent content is 39 percent or 3.17 pounds per gallon. You would base your application on the acid equivalent content.

Net Contents

Stated in pounds or ounces or in pints or gallons, the net contents figure indicates the amount of the formulation in the container. This figure plus the ingredient statement will tell you how much to buy for the job you have to do.

Uses

The specific crop, livestock, or site to be treated and the specific pests to be controlled will be listed in the use section of the label. It is illegal to use a pesticide for any purpose not included on the label. Geographic or time limitations also may be indicated here.

Directions

In this section, you can get specific information on how much, where, when, and how to apply the pesticide.

How much: The rate of application of the formulation in terms of weight or volume per acre or thousand feet of row, or the amount to mix in a given volume of water will be given.

Where: Directions here will be to apply to the furrow, band over the row, broadcast, apply to the foliage, cover bark and twig surfaces, etc.

When: The time of application will be given (preplanting, preemergence, postemergence, at a certain stage of plant development, dormant period etc.). Preharvest limitations may be given here, or they may appear in a separate limitations section. The minimum time that must elapse between treatment and harvest will be given, and the maximum number of treatments may be given.

How: The equipment to use, whether to mix the pesticide with water or oil, instructions for incorporating it into the soil, the type of spray pattern, and similar how-to-do-it information will be provided here.

Warnings and Precautions

In this section, you will find the information you need to apply the pesticide safely. Information on your own safety, the safety of other people, and the safety of crops and livestock being treated will be included. If the pesticide presents a threat to fish, wildlife, or other nontarget organisms in the environment, this will be stated.

The precautions are based on certain key words: **Danger, Warning,** and **Caution**. Pesticide formulations that are highly toxic must have the word **Danger** plus **Poison** in red letters and an illustration of the skull and crossbones. Moderately toxic formulations must display the word **Warning**. Products that are slightly toxic are denoted by the word **Caution**.

All pesticide labels must include the statement **Keep out of the reach of children.**

You will also find the name and address of the manufacturer, the establishment number, and the Environmental Protection Agency registration number on pesticide labels.

Classification

If the pesticide has restricted uses, the restricted use statement will be at the top of the front panel of the label.

Application of Pesticides

When the need for a pesticide arises, the objective is to deliver an effective amount of a suitable pesticide to the target pest. In some cases the pesticide may be a preventive treatment; in others it is curative. The pesticide formulation and equipment used must be suitable for the job.

TYPES OF FORMULATIONS

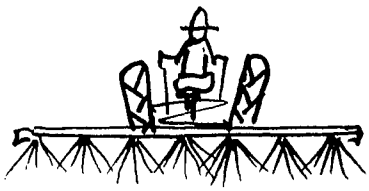
A basic chemical, or active ingredient, can rarely be used as originally manufactured. It is usually mixed with other substances to put it in a form that has good physical and handling properties and can be safely, easily, and accurately applied. This modification of the active ingredient into a mixture is called a pesticide formulation and is made up of active and inert ingredients. The final pesticide formulation is ready for use either as packaged or when diluted with water or other carriers.

Liquids

Emulsifiable Concentrates (EC): An emulsifiable concentrate is a liquid formulation of a pesticide that can be mixed with another liquid to form an emulsion. (An emulsion is one liquid that is dispersed, usually as very small globules, throughout another liquid.) An EC usually contains 2-6 pounds per gallon of active ingredient. Water usually is the liquid with which an EC is mixed, but some EC formulations are made to be added to oil or to other petroleum carriers.

Many active ingredients in pesticides are not soluble in water but are soluble in oils or other solvents. In an EC, the active ingredient is dissolved in an oil or solvent and emulsifying agents and other adjuvants are added to the formulation so the EC can be mixed with water to form a "milky" emulsion. The emulsion can then be sprayed conveniently. Little agitation is required with ECs. Some crops are sensitive to the ECs of some insecticides so different formulations of the active ingredient (wettable powders or dust formulations, for example) may have to be used on them.

High Concentrate Liquids, Spray Concentrates. These formulations may be thought of as special EC formulations. They usually contain a high concentration of the active ingredient, as much as 8 or more pounds per gallon.



Most are designed to be mixed with water or oil and contain wetting agents, stickers, and other adjuvants. Ultra low volume (ULV) concentrates are designed to be used directly without further dilution and contain little but the pesticide itself.

Low Concentrate Liquids. These formulations are usually solutions in highly refined oils that contain low amounts of the active ingredient. Generally, they are designed to be used as purchased, with no further dilution. This type of formulation is often sold for use in controlling household pests, for mothproofing, or for use in barns as a space spray or a spray for livestock.

Flowables (F or L). Some active ingredients can be manufactured only as solid, or, at best, semi-solid materials. They usually have relatively low solubility in water or in other organic solvents. These pesticides are often formulated as flowable liquids. The active ingredient is very finely ground and suspended in a liquid along with appropriate suspending agents, adjuvants, etc. In this form the formulation can be mixed with water and applied. Flowables do not usually clog spray nozzles, require only moderate agitation, and in many ways can be handled as easily as EC formulations.

Solutions (S). Some active ingredients are completely soluble in water or organic solvents; in their original state they are liquids. The pesticide is formulated in an appropriate solvent or water and exists in the true solution, or molecular, state. Solutions properly prepared for special uses do not leave unsightly residues and will not clog spray equipment. Some of these formulations, however, can damage crops, so an alternative formulation may have to be used.

Aerosols. The active ingredient(s) in aerosols is in a formulation in a can under pressure. One or more pesticides may be in the same formulation. The propellant drives the formulation out through a fine spray opening. Usually the percentage of active ingredient(s) in an aerosol is very low. Convenience of use is the major advantage. Aerosols are sold mainly for garden and home use, not for agricultural use. Some are used in greenhouses, barns, etc.

Pressure Liquified Gases. Some active ingredients at atmospheric pressure are gases, not liquids or solids. When placed under pressure in a container, some still remain gases, but many turn to liquids. These formulations are stored under pressure (high or low, depending on the product). When applied, they usually are injected into the soil, released under tarps, or released into a vessel such as a grain storage elevator. Some formulations of nematicides, fumigants, and rodenticides are examples of this type of formulation.

Note that some liquid formulations not requiring storage under pressure turn to gases or vapors after they have been applied to the soil or a crop. If the formulation is an insecticide, the vapors of the active ingredient often do most of the killing of the pest. In the case of a herbicide, the liquid has to be incorporated into the soil before it turns to a gas and is lost to the atmosphere.

Dry Formulations

Dusts (D). A dust formulation usually consists of the active ingredient mixed with talc, clay, powdered nut hulls, volcanic ash, or other such materials. The formulation is very finely ground to a fairly uniform particle size. Adjuvants are often added to ensure that the formulation will store well and handle acceptably when applied. Some active ingredients are formulated as dusts because in that form they do not cause phytotoxicity to the economic crop, whereas an EC formulation might be quite phytotoxic to the crop. The percentage of active ingredient in a dust usually is low. Dusts are used dry; never mix them with water. Dust formulations are available for use on seeds, plants, and animals.

Granules (G). Granular formulations are dry formulations usually made by applying a liquid formulation to granules of clay or other porous materials such as corn cobs or walnut shells. The granules are prepared in advance to a standard size before the liquid formulation is applied. The liquid is adsorbed or absorbed (or both) on the porous material. Additional adjuvants or conditioning agents may be added to granular formulations so they handle well. The

percentage of active ingredient in granular formulations is lower than that of an EC but usually higher than that of a dust. From the applicator's standpoint, they are usually safer to apply than EC's or dusts. Granular pesticide formulations are most often used as soil treatments. They can be applied directly to the soil or over plants, since they do not cling to plant foliage, although they can be trapped in the whorls of some plants.

Wettable Powders (WP). Wettable powders are dry powdered pesticide formulations similar in appearance to dusts but unlike dusts in that they contain wetting and dispersing agents. Wettable powders are usually much more concentrated than dusts, containing 15-95 percent active ingredient (most formulations contain more than 50 percent). They are made to be mixed to form a suspension spray. Agitation is required in the spray tank to keep the formulation in suspension, since the formulation does not form a true solution. Because of the nature of the active ingredient, some pesticide products can be formulated into wettable powders but not into ECs. Good wettable powder formulations spray well and do not clog nozzles, but they are abrasive to pumps and nozzles. Most wettable powder formulations are less likely to damage sensitive plants (be phytotoxic) than are ECs. Wettable powders and ECs are the most widely used formulations.

Soluble Powders (SP). Soluble powders, like wettable powders, are dry formulations, but when souble powders are added to water, they completely dissolve and form solutions. Agitation in the spray tank is sometimes required to get them into solution, but once in solution they require no further agitation. The percentage of active ingredient in an SP usually is high. Compared to ECs and WPs, not many SP formulations are available.

Poisonous Baits. A poisonous bait formulation is a food or other edible substance mixed with a pesticide that will attract and be eaten by pests and cause their death. Bait formulations are useful in controlling mice, rats, and other rodents and animals. Baits are also used for controlling ants and flies or other insects, including some soil pests. Whole area or just spot treatment can be accomplished with bait formulations. Baits can be used both in buildings and outdoors. The percentage of active ingredient in bait formulations is low compared to EC and WP formulations.

APPLICATION EQUIPMENT

The rapidly expanding use of pesticides places increasing emphasis on the need for understanding the proper care and calibration of spray equipment. Precise control of the amount of chemical applied is essential to obtaining efficient control of the pest involved and to avoiding damage to desirable plants and animals in the area. Applying too little chemical wastes time and materials; applying an overdose adds to the cost and may leave dangerous residues.

Care and calibration go hand-in-hand. Before any sprayer can be reliably calibrated, it must be in good mechanical condition. In fact, inspecting the equipment is the first step in calibration. Sprayers are particularly susceptible to poor maintenance, which is costly in terms of excessive replacement of parts and poor control over application of the pesticides. Pesticides may be corrosive, so thorough cleaning after each use is essential.

The preliminary inspection should detect any loose bolts or connections. Check hoses and transmission lines for general condition and evidence of leaks. Inspect strainers and screens and clean them if necessary. Replace any parts that are worn or damaged.

The Tank

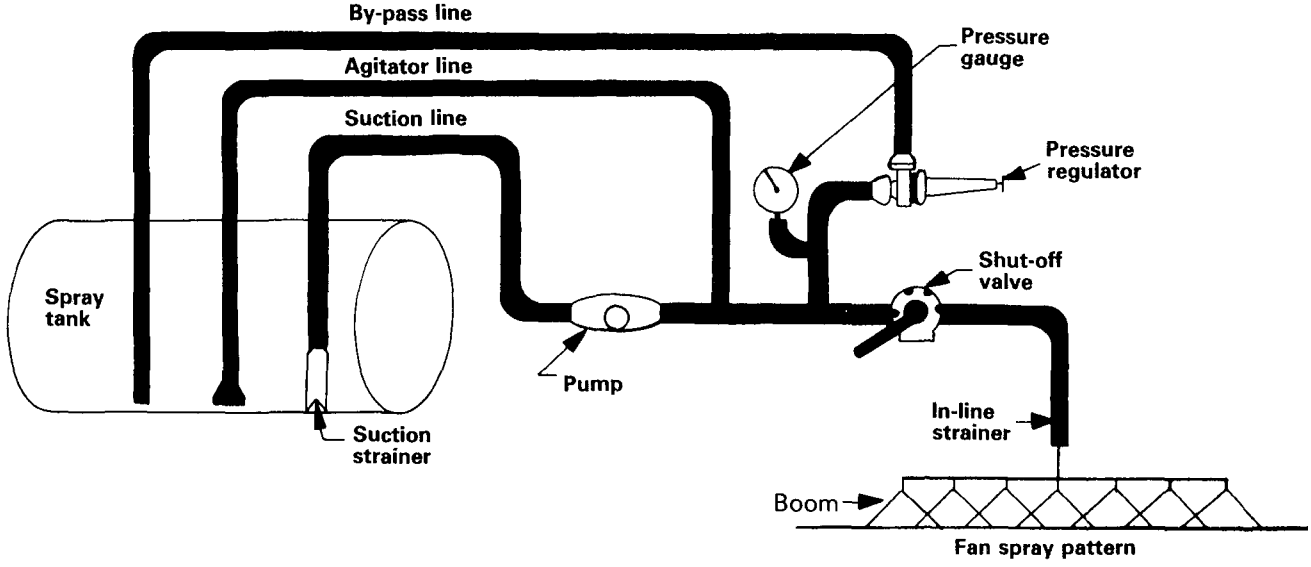
The sprayer tank should be of a material that can not be corroded by the solutions handled. Fiberglass and stainless steel tanks are very corrosion resistant and satisfactory for most chemicals. Plastic coated tanks are also corrosion resistant, but they are less durable than the fiberglass or stainless steel ones. Cracks or chips in the coating will expose the base metal to corrosion. Metal tanks can be used for noncorrosive solutions if precautions are taken to prevent rust and scale. Whatever the material, the tank should have a large opening to allow for thorough inspection and cleaning.

The Pump

Roller and piston pumps are the types most commonly used on agricultural sprayers. Gear, vane, or diaphram pumps may be used for special applications.

The pump must supply the solution to the distribution system under pressure and at a reasonably even flow. Its capacity must be sufficient to supply the nozzles and agitator, plus a slight excess to operate the relief valve. It is wise to select the pump slightly oversize to allow for some loss of efficiency due to wear.

Sprayer System



The Pressure Regulator

The pressure regulator, or relief valve, maintains the required pressure in the system. It is a spring-loaded valve that opens to prevent excess pressure in the line and allows some of the solution to return to the tank. Most pressure regulators are adjustable to permit changes in the working pressure of the system.

The Pressure Gauge

A pressure gauge should be included in every sprayer system. Nozzles are designed to operate within certain limits, and every operator should know the pressure being used. The gauge also will indicate malfunctions by showing fluctuations in pressure. Select a gauge designed for the pressure you will be using. For example, don't use a 300 pounds per square inch (PSI) gauge for a 35 PSI system. Accurate readings with this setup would be virtually impossible.

Agitation

Solutions and emulsions can be sufficiently stirred by the return liquid from the regulator bypass line. Wettable powders require more agitation to keep them in suspension. Mechanical agitation is best, but where this is impractical, hydraulic jet agitation usually is used.

Jet agitators use liquid from the sprayer's pressure system. The line to the agitator should be connected between the pump and any cutoff valves to the nozzles so agitation will continue when spraying is stopped for turning or other momentary delays. The amount of liquid required for agitation depends on the size of the sprayer tank. Recommended flow rates are shown below.

Tank size, gallons	Agitator flow, gallons per minute
80	2.5
100	3.0
150	4.5
200	6.0
250	7.5

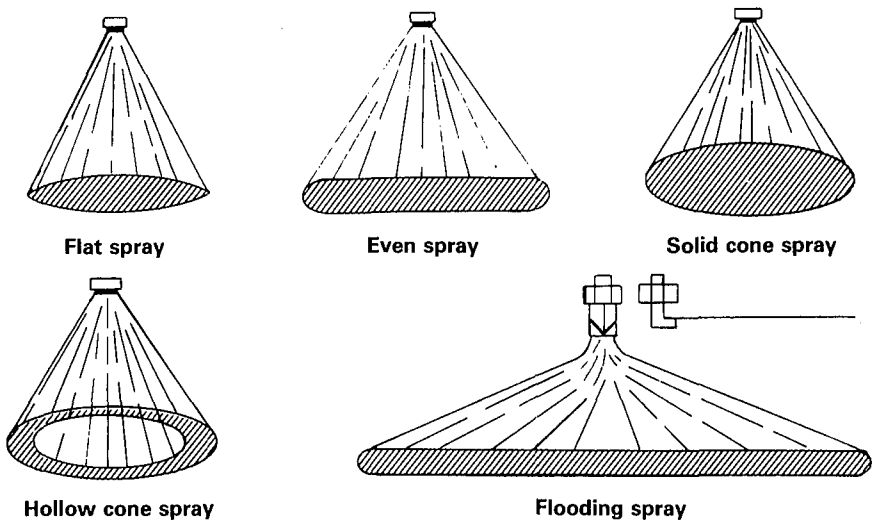
Strainers

Strainers or screens are placed at various points in the system to exclude foreign material that would wear out precision parts or clog the system. Screens are normally placed at the entrance to the pump intake line, in the line from the pressure regulator to the boom, and in each nozzle. Usually 25- to 50-mesh screens are used in the intake hose, 50- to 100-mesh screens are used in the boom supply, and screens the size of the nozzle tip opening are used in the nozzle. For spraying wettable powders, all screens should be 50-mesh or coarser.

Nozzles

Nozzles should be selected to give the proper particle size, spray pattern, and application rate within the recommended range of pressures. Each nozzle is rated as to application rate at a specified pressure and ground speed. These two factors can be varied, within limits, to change the application rate. Too high pressure on a given nozzle will result in a small particle size and a distorted spray pattern. Excessive drift is a symptom of this condition. Pressure that is too low results in large droplets and an incomplete spray pattern and uneven coverage.

Nozzle Spray Patterns



The flat spray nozzle produces a rather coarse spray in a fan-shaped pattern. It produces even coverage when overlapped with other nozzles in boom sprayer applications. It is suitable for most field weed control and some insect control where penetration of the foliage is not necessary. A wide angle nozzle with this pattern can be operated close to the ground to minimize drift.

The even spray nozzle applies a more uniform coverage across its pattern than the flat spray nozzle. It is used for band applications in row crops where there is no overlap from adjacent nozzles.

Solid and hollow cone nozzles give a smaller droplet size than the flat or even spray ones and are used for insect and disease control where penetration of the foliage is desired and some drifting is not objectionable. The round pattern does not produce an even coverage when placed in line on a boom.

The flooding spray nozzle produces a wide pattern and is used close to the ground. It operates at low pressure, and the danger from drift is very low.

Spray pattern angle, spacing on the boom, and height from the target area must all be considered to get the proper overlap for uniform coverage.

Rate of Application

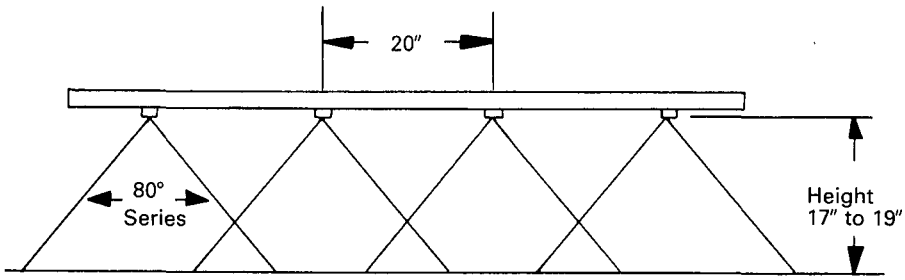
Application rates of most chemicals are quite small, yet the spray equipment must apply the chemical uniformly over the area to be covered. The chemical is mixed with a carrier, usually water or oil, to facilitate uniform distribution. The amount of carrier varies with the chemical and the area to which it is applied. **Read the label on the chemical container for recommendations.** Calibrate the sprayer to apply the proper amount of carrier; then add the chemical to the carrier in the right proportion for the desired application rate. Sprayers that use air as a carrier, such as mist blowers and some bi-fluid systems, require calibration of the liquid system to supply the proper amount of concentrate to the air stream.

Calibration

Calibration of the machine simply involves adjusting it to apply the right amount of material in the right place. Many methods and tables have been used, and most of them are sufficiently accurate. The main thing to do is to select a method you understand and then perform it faithfully. Be sure to check calibration periodically to compensate for nozzle wear.

The application rate for field sprayers is usually given in gallons per acre (GPA), the speed at which the sprayer moves over the ground is given in miles per hour (MPH), the output of the nozzles is listed in gallons per minute (GPM), and the pressure is given in pounds per square inch (psi). Ground speed, pressure, and nozzle size all can be varied to

change the application rate. Increasing the ground speed decreases the application rate, increasing the pressure increases the application rate, and increasing the nozzle size increases the application rate.



NOZZLE CAPACITY CHART

Tip no.	Press. in PSI	Cap. in GPM	Gallons per acre					
			2 mph	3 mph	4 mph	5 mph	7.5 mph	10 mph
	20	.28	43	28	21	16.8	11.2	8.4
8004	25	.32	47	31	24	18.7	12.5	9.4
(*26 GPA)	30	.35	51	34	*26	21	13.7	10.3
(50 Mesh)	40	.40	59	40	30	24	15.8	11.9
	50	.45	66	44	33	27	17.7	13.3
	60	.49	73	49	36	29	19.4	14.6

Nozzles are sometimes designated by nominal sizes in terms of GPA output. To achieve this rate, they must be operated at a specific pressure and ground speed. Such information is listed in the specifications for that nozzle. Consult nozzle capacity charts for rates at other pressures and ground speeds.

The sprayer must be calibrated by measuring the amount of material actually applied over the terrain to be sprayed. The following procedure is simple and accurate.

1. Determine the distance your spray must travel to cover 1 acre. Do this by dividing the spraying width (in feet) into 43,560 (the square feet in an acre).
2. Mark off this distance in the field or area to be sprayed. A fraction of this distance may be used to equal the same fractional part of an acre.
3. Prepare the sprayer and set the pressure where it will be used for spraying.
4. Select a ground speed that is safe and mark the throttle setting or note the speed so you can duplicate it later.
5. Fill the tank to a measurable mark with water.
6. Spray over the marked course. Be precise in turning the spray on and off at the start and end of the course. Maintain a uniform speed.
7. Measure the amount of water necessary to refill the tank. If the carrier used in spraying is to be an oil solution and you use water for calibration, add 10 percent to the volume measured. If your course covers a full acre, the amount necessary to refill is the GPA you are applying. If you chose a shorter course to represent a fraction of an acre, the refill amount will be the same fractional portion of the GPA.

If the application rate is not the same as recommended, change the ground speed, pressure, or nozzles and repeat the test run. Do not operate the nozzles above or below the recommended pressure range.

Use of Tables

Calibration tables may be available for the sprayer you are using. If so, they will specify a distance to travel in calibrating the machine, after which you can read directly the GPA applied according to the ground speed (MPH), spray pattern width (feet of boom or inches of nozzle spacing), and amount of material sprayed. This method can be used to calibrate at any time by catching the liquid at the nozzle; refilling the tank is unnecessary.

Formulas

If tables and other guides are not available, the proper relationship of application rate, ground speed, and flow rate can be calculated by using formulas. The following formula holds true for boom sprayers.

$$GPA = \frac{5940 \times GPM}{MPH \times S}$$

where GPA = gallons per acre application rate,
GPM = gallons per minute discharge from each nozzle,
MPH = miles per hour, and
S = nozzle spacing on the boom in inches.

The formula can be rearranged for finding flow rate and ground speed.

$$GPM = \frac{GPA \times MPH \times S}{5940}$$

$$MPH = \frac{5940 \times GPM}{GPA \times S}$$

Calculations involving total boom width or broadcast nozzles require values for total sprayer output and total width covered.

$$GPA = \frac{495 \times GPM}{MPH \times W}$$

where GPA = gallons per acre application rate,
GPM = gallons per minute total discharge,
MPH = miles per hour, and
W = total width sprayed in feet.

Also: $$GPM = \frac{GPA \times MPH \times W}{495}$$

$$MPH = \frac{495 \times GPM}{GPA \times W}$$

To check ground speed:

$$MPH = \frac{\text{Distance traveled in feet}}{1.47 \times \text{Seconds required to travel measured distance}}$$

Handgun and knapsack spraying operations present problems because "ground speed" is difficult to judge. One method of gauging application rates with this equipment is to calculate the time required to cover a given area, mentally lay out this area, and spray for the required period of time in covering the area.

Minutes to cover 1,000 square feet = $\frac{1.38 \times GPA}{GPH}$

Minutes to cover 100 square feet = $\frac{0.138 \times GPA}{GPH}$

GPH can be determined by collecting the liquid from the nozzle for 3¾ minutes. The number of cupfuls collected is equivalent to the GPH output of the sprayer.

Sprayer maintenance is essential. Be sure you follow these guidelines:

1. Use only clean water.

2. Keep proper screens in place.
3. Never use a metal object for cleaning nozzles.
4. Flush a new sprayer before you use it.
5. Do not lock a pump solidly to a tractor.
6. Lubricate your pump properly. Fill it with antifreeze or light oil when it isn't in use.
7. Clean the sprayer thoroughly after each use when changing chemicals before storage. To remove 2,4-D and similar materials, follow this procedure:
   a. Remove and clean all screens and nozzles with kerosene.
   b. Pump kerosene or fuel oil through the sprayer. Rinse the tank with kerosene or fuel oil.
   c. Circulate a cleaning solution (1 pound detergent with 40 gallons of water) through the bypass for 30 minutes and flush part of it through the sprayer. Empty the remainder.
   d. Fill the tank with water and ammonia. Add 1 quart of household ammonia to 25 gallons of water. Pump enough solution through the hose and nozzles to fill these parts. Fill the tank, close it, and leave it for 24 hours.
   e. Empty the sprayer and rinse it with water.
   f. The day before using the sprayer, fill the tank with clean water. Drain the sprayer before using it.
8. For extended storage periods, coat exposed metal parts with light oil to prevent rust.

There are several devices available from dealers to assist in **calibrating granular applicators.** The rate of application can be checked by collecting the material released in a certain distance. Make sure all applicators are releasing the same amount of material.

To calculate the rate per acre, use this formula:

$$\frac{43{,}560 \times \text{pounds material applied}}{\text{Distance treated (feet)} \times \text{band width (feet)} \times \text{number of bands.}} = \text{lb./acre}$$

Use table 1 for any calibrations that require measurement conversions.

Table 1. Conversion of measurements

Liquid Equivalents

1 gallon (U.S.) equals 3,785 milliliters or cubic centimeters.
" " equals 256 tablespoons.
" " equals 231 cubic inches.
" " equals 128 fluid ounces.
" " equals 16 cups.
" " equals 8 pints.
" " equals 4 quarts.
" " equals 0.8333 imperial gallon.
" " equals 0.1337 cubic foot.
1 liter equals 1,000 milliliters or 1.057 quarts (U.S.).
1 quart (U.S.) equals 32 fluid ounces.
1 pint equals 16 fluid ounces.
1 fluid ounce equals 29.57 milliliters or 2 tablespoons.
1 tablespoon equals 3 teaspoons or 15 milliliters.
1 teaspoon equals 5 milliliters.
16 tablespoons equals 1 cup.
1 cup equals ½ pint.
2 cups equals 1 pint.
1 cubic foot of water weighs 62.4 pounds, containing 7.48 gallons, or 1 gallon of water weighs 8.35 pounds.

Weight Equivalents

1 pound equals 16 ounces or 7,000 grains or 454 grams.
1 ounce equals 28.4 grams.
1 gram equals 1,000 milligrams.
1 pound equals approximately 1 pint of water.

Linear Equivalents

1 yard equals 3 feet or 36 inches.
1 rod equals 16½ feet or 5½ yards.
1 chain equals 4 rods or 66 feet.
1 mile equals 5,280 feet or 1,760 yards or 320 rods or 80 chains.
1 meter equals 39.3 inches or 100 centimeters or 1,000 millimeters.
1 micron equals 1/1000 millimeter.

Area Equivalents

1 square rod equals 272.25 square feet.
1 acre equals 43,560 square feet or 160 square rods or 0.4 hectare.
1 square mile equals 1 section or 640 acres.

Acre Equivalents

Length	plus	Width	equals	Acres
208.7 feet	"	208.7 feet	"	1
500 feet	"	87.0 feet	"	1
1,000 feet	"	43.5 feet	"	1
2,000 feet	"	21.7 feet	"	1
4,000 feet	"	10.8 feet	"	1
5,000 feet	"	8.7 feet	"	1
1 mile	"	8¼ feet or ½ rod	"	1
1 mile	"	1 rod	"	2
8¼ miles	"	1 foot	"	1

Liquid Volume Per Acre Equivalents

Volume per square rod	equals	Gallons per acre
24 cubic centimeters	"	1
47 cubic centimeters	"	2
71 cubic centimeters	"	3
95 cubic centimeters	"	4
118 cubic centimeters or ½ cup	"	5
1 cup	"	10
1 pint	"	20
1 quart	"	40
1 gallon	"	160

CONTROLLING PESTICIDE DRIFT

The Drift Problem

Pesticide drift is the movement of a pesticide to areas other than the intended area of application. Spray or dust particle drift occurs at the time of application when small spray droplets or dust particles are carried by air movement from the site of application. Vapor drift is the movement of pesticide fumes from the site of application when the pesticide evaporates. These vapors move by diffusion or air movement.

Pesticide drift can harm sensitive crops, ornamentals, gardens, livestock, wildlife, or people. Bodies of water, streams, or buildings can be contaminated. Drift onto crops can result in an illegal residue if the residue on the crop

exceeds the level for which tolerances have been established or if no tolerance has been set. Poor performance can result if excessive drift results in too low a rate of application.

Factors Affecting and Techniques for Controlling Drift

Chemical. Potent chemicals are a great drift hazard because small amounts can result in problems. For example, a fraction of an ounce per acre of herbicides such as 2,4-D, dicamba, and picloram can affect sensitive crops. Some chemicals volatilize rapidly, but others do not volatilize fast enough to build up injurious concentrations.

Formulation. Vapor drift can be avoided by using relatively nonvolatile formulations and invert emulsions (see table 2). Low volative 2,4-D formulations reduce the vapor drift hazard. Dusts drift more readily than sprays. Measurements of drift from aerial applications showed from 5 to 100 times more drift from dusts than from sprays at distances of 100 feet to ½ mile from the flight pattern.

Particle or Droplet Size. Large particles or droplets have less drift potential than smaller particles or droplets (see table 3). But consideration must also be given to adequate coverage.

Table 2. Droplets of emulsions by size class from fixed-wing aircraft

	Droplet size class, microns			
Emulsion	0-150	150-300	300-450	450-900
	percent			
Standard	37	43	14	6
Invert, 45°[a]	10	45	22	21
Invert, 15°[a]	15	51	21	13

[a]Orientation of nozzles back from the vertical position.

Table 3. Distance water droplets drift while falling 10 feet in a 3 mile per hour wind

Droplet diameter, microns[a]	Classification	Drift, feet
30	Cloud	500
100	Mist	50
200	Drizzle	16
500	Light rain	7

[a]1 micron = 1/25000 inch.

Table 4. Effect of thickening agents on spray drift

Spray	Drift as percentage of water solution spray
Water	100.0
Inverted emulsion	40.9
Hydroxyethylcellulose	9.4
Particulate	.9

Table 5. Lifetime of water droplets, 40 percent relative humidity, 59°F.

Initial diameter, microns	Life, seconds	Time to fall 20 feet, seconds
50	4	[a]
100	16	20[b]
200	63	10

[a]Droplet will only survive about 1 foot of the free fall.
[b] Evaporation will decrease both size and rate of fall, so the droplet will not reach the ground.

Spray nozzles produce a wide range of droplet sizes. Thickened sprays are coming into use to increase the percentage of large droplets (see table 4). Thickened sprays, however, do not completely eliminate the fine droplets. Application techniques and precautions are still important in applying thickened sprays to reduce drift problems.

Specific Gravity or Density of Particles. "Lighter" particles tend to stay airborne longer, so they drift farther. Oil droplets are lighter than water droplets.

Evaporation Rate. After spray droplets are released, evaporation reduces their size, which tends to keep them suspended longer. Water evaporates more rapidly than oils (e.g., 35 times as fast as diesel fuel). Small droplets may completely evaporate before they reach the ground (see table 5).

Nozzles and Pressure. Nozzles are designed to convert spray liquids into droplets and to distribute them in a uniform pattern. Nozzle construction and the pressure of operation determine the size and uniformity of droplets.

At low pressures the liquid escapes from the nozzle tip as a liquid film. As the film expands, it forms droplets at the outer edge as a result of the surface tension of the liquid. As pressures increase, droplet formation occurs closer to the nozzle tip, with the formation of smaller droplets. At high pressures, droplets are formed directly from the nozzle tip as a result of hydraulic force. Under high pressures, droplets may be of fog and mist size, creating a drift hazard.

Most nozzles have a relatively low pressure that permits droplet formation as a result of surface tension. If nozzles are operated at this pressure, there will be a minimum amount of mist size droplets to cause spray drift. Large nozzles can be used at low pressure to deliver the same GPA as small nozzles at high pressure.

Height of Release. The distance and thus the time required for droplets to reach the ground are directly affected by the height of release. Wind velocities are usually lower close to the ground. Sprays should be released as near the vegetation or soil surface as will permit adequate coverage. Using drop nozzles to release the spray below the crop canopy will minimize drift.

Weather. Weather conditions can affect the potential for drift (see table 6). **Air movement**, both horizontal and vertical, is one factor that can affect this potential.

In general, air is least turbulent just before sunrise and again just after sunset and on through the night. Air usually is most gusty and turbulent between 2 and 4 p.m. Differences between the temperature of air at ground level and that of higher air determine the amount of turbulence. Normal daytime heating of the soil causes the air near the soil surface to be warmer than the air aloft. The warm air at the lower levels rises, setting up air currents. The temperature differential usually is least during early morning or late evening, which accounts for the calmer conditions at those times. As the temperature differential increases, air currents may carry particles for long distances. Avoid application when this condition exists.

If the air near the soil surface is cooler than the air above (an "inversion" condition), the warm air aloft remains on top and no vertical mixing can take place. Low winds with a high inversion (ground air 2 to 5 degrees cooler than the air above) may cause the smallest spray droplets or dust particles to remain suspended in the layer of cold undisturbed air and eventually to move out of the area. Avoid application under this condition also.

Temperature has effects on air movement, as discussed above. In addition, high temperatures increase losses of volatile herbicides. The carbamates, dinitro compounds, and high volatile esters of 2,4-D; 2,4,5-T; and other phenoxy compounds volatilize rapidly at

Table 6. Micro-weather effects on drift

Wind speed at 8 feet, miles per hour	Temperature at 8 feet, ° F	Temperature difference, ° F at 32 feet minus ° F at 8 feet	Relative humidity, percent	
3-5	70-95	0	20-50	Best weather for application.
2-3	70-100	+2 to +5	40-50	Calm, cool surface air, strong inversion; drift potential 3 to 10 times higher than with best conditions.
8-10	70-110	0 to −5	20-40	Windy, turbulent; drift potential 3 to 6 times higher than with best conditions.

temperatures above 80° F. At temperatures above 90° F, even the low volatile esters of 2,4-D and other phenoxy compounds become significantly volatile.

High temperatures also increase the rate of evaporation from spray droplets, which means the droplets stay airborne longer.

The relative **humidity** affects the rate of evaporation from spray droplets, the rate being faster at low relative humidities.

Temperature, humidity, and moisture conditions indirectly affect the potential for drift problems because they affect the susceptibility of the crop to the herbicide. Crops are generally more susceptible to injury under favorable growing conditions. But favorable growing conditions following herbicide damage can promote recovery.

Summary

Pesticide drift control should be a consideration during every pesticide application. Severe problems can be avoided by giving proper attention to chemical formulations, equipment, and weather considerations. To reduce drift:

- Use low volatile formulations.
- Use low pressure.
- Use large nozzles.
- Use high volume.
- Release spray near crop or soil surface.
- Avoid spraying at high temperatures.
- Spray when wind is low and blowing away from sensitive crops or areas that should not be contaminated.

Pesticides and Our Environment

Our environment includes our surroundings and all the many forms of life that live in those surroundings. Every plant or animal in every environment is affected by other plants or animals in the same environment. Physical factors such as rain, temperature, and wind also are part of the environment. We can't do much about them, but we do have control over such factors as waste disposal, housing developments, super highways, and agricultural practices, including the proper use of pesticides.

People need to live with clean water and air, with food that is not harmful, and in an environment that will not threaten their health and safety. Pesticide applicators are often blamed for environmental abuse as the public becomes increasingly critical of pesticides. As an applicator, you must use pesticides in such a way that the environment is harmed as little as possible.

Many of those who use pesticides consider them tools for preserving or improving the environment. Others think pesticides are pollutants. Because a weed is considered "a plant out of place," a pesticide pollutant can be considered a "tool out of place."

How Pesticides Harm the Environment

Application of pesticides that are not labeled for the use planned can result in plant injury, confiscation because of illegal residues, or environmental damage. Even the use of properly labeled pesticides, if they are not carefully selected or if they are carelessly used, can result in injury to or killing of plants, people, domestic animals, birds, bees, fish, or other wildlife either directly because of their highly toxic nature or indirectly because of their persistence, accumulation, or biological magnification.

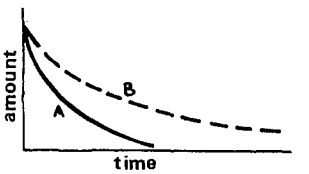
Direct Killing of Nontarget Organisms

Pesticides can injure or kill nontarget organisms by direct contact. Bees can be killed if the crop is treated while they are working in the field. Herbicides applied to roadside brush can drift out of the area and kill crops or ornamentals. Runoff from a recently sprayed field can kill fish in streams or ponds below a field. Aquatic life in streams can be wiped out by careless tank filling and poor container disposal. These kills are spectacular and can result in poor publicity, lawsuits, fines, and loss of certification.

Persistence, Accumulation, and Biological Magnification

Many pesticides break down rapidly. They remain on the target or in the environment only a short time before being changed into harmless products by microorganisms, soil chemicals, sun, water, etc. Some pesticides can be highly toxic and can cause heavy local kills of beneficial organisms. Others are relatively harmless to the environment. If used under the right conditions, even the highly toxic materials can be safe to the environment. On the other hand, misuses or spills of relatively nontoxic pesticides can be very harmful to the environment.

Serious environmental problems are caused by pesticides that are slow to break down and that accumulate in living tissue.



Accumulative pesticides can build up in the bodies of animals, including people. They can build up until they are harmful to the individual organism or until they are harmful to the meat eater that feeds on animals with high pesticide buildups.

Persistent pesticides stay in the environment without change for long periods of time, which is often desirable because of the resulting long term control. Usually these pesticides do not easily react with sun, oxygen, or heat; are not easily broken down by microorganisms; are only slightly soluble in water; and can remain in the environment for many years. Persistent pesticides do not always accumulate. Atrazine, for example, persists in the soil but does not seem to accumulate in the bodies of animals. It can be injurious to sensitive crops planted on the same soil in the following year but appears to be of little hazard to the environment outside the treated area.

Pesticides that are both **persistent and accumulative** can be hazardous if used in such a way that they can escape from the target or treated area. If persistent, they may remain in the soil, in the water, or on the target long enough so plants or animals are exposed to them. An accumulation of pesticide in an organism may or may not be harmful to the organism itself, but it is a definite threat to the animals that feed on it and to other animals in the food chain. The term food chain is used to describe how all organisms depend on each other. Each animal has a place in the chain, depending on the type of food it eats. Animals that eat only plants are at the bottom, animals that feed on the plant eaters are on the next level, and animals that eat meat are at the top of the chain. Meat eaters that feed on other animals that have accumulated deposits of pesticides may receive enough pesticide to be poisoned without ever directly contacting the pesticide. Humans, as plant and meat eaters, can get high doses of pesticides in this way, although we usually are protected by residue tolerances.

Pesticide Movement in the Environment

Pesticides become problems when they move off target. This may mean drifting out of the target area, moving in soil through runoff or erosion, leaching through the soil, being carried out as residues, etc. Of course, pesticide-treated fields are not expected to be wildlife refuges, but care must be taken so pesticides do not move out of the field. They should be applied in a manner and at a time when they will do the least damage to beneficial organisms that use the treated area.

Soil and Pesticides

Soil increases in importance as the need for food increases. Large acreages of good agricultural soil are lost to highways, housing developments, and shopping centers. We must keep the agricultural land that is left fertile and healthy. Poor soil practices and misuse cause poor yield and second class crops, especially if root vegetables or forage crops are planted. Overdoses of pesticides resulting from poor calibration, ignorance, or international misuse may result in sterile soil. Pesticides that remain for long periods in the soil may limit planting to only a few crops that will not be harmed by the chemicals. For instance, atrazine applied as an herbicide for corn becomes a persistent pollutant if a grower wishes to plant sensitive crops such as vegetables the following year. To avoid these harmful effects, the whole crop rotation plan should be considered when a pesticide is selected.

Even those pesticides deposited on the target crop move into the soil. They may be washed or brushed off, incorporated into soil with dead plant parts, or eaten with plant materials by farm animals and later excreted to become pollutants.

Because poor agricultural practices may allow soil erosion, pesticides can move out as a result of heavy rains or flash floods immediately after cultivation. Plowing under sodded areas allows for the movement of pesticides in eroding soil both in water and air. Every effort should be made to prevent such soil movement.

Air and Pesticides

Air is necessary for any plant or animal to live. It is the source of oxygen for breathing, and it receives carbon dioxide waste. It also receives many other substances and can carry them for long distances. Some of these, such as the moisture that results in rain, are essential; others, such as auto exhausts, bad odors, or pesticide dusts and vapors, are disagreeable and can endanger the health and life of people, domestic animals, crops, and wildlife. Pesticide drift can cause serious environmental contamination. Pesticides in the air are not controllable and can settle into waterways, neighboring crops, wooded areas, houses, or barnyards. Pesticides have been known to move across several states on prevailing winds to contaminate rainwater and soil. Even gentle breezes can carry herbicides away from the target to kill or damage a sensitive crop. Air can carry the herbicide as fine droplets that drift a long way, or it can carry volatile formulations in the form of a gas that will drift even farther. Insecticides or fungicides can be carried by drift to neighboring crops and may result in illegal residues and crop losses. Pesticides can drift into waterways and cause serious damage to aquatic life. As a careful applicator, always be aware of the wind velocity and direction and plan pesticide applications accordingly. And always consider the use of low volatile pesticide formulations and low risk application methods.

Water and Pesticides

Water is necessary for all life. Although polluted water can be used for many of our needs, we cannot drink it or bathe in it. Most fish and other marine life can survive only slight changes in their water environment. Many pesticides are harmful to fish and other marine life, even if they are present in only tiny amounts. Marine life can be killed outright by pesticides in water, or there may be chronic effects. The behavior of the affected organism can be changed making it easier for predators to catch and kill it. Pesticide contaminated eggs or young organisms may not hatch or may not survive after hatching. Obviously, clean water is essential!

Pesticide contamination of water usually causes the most serious environmental concern. Most pesticide movement through air or soil ends up in water, and most of the residue problems affecting wildlife have been caused by pesticides in water. Avoiding pesticide contamination of water is particularly important in avoiding accumulation and biological magnification, as well as in preventing serious fish kills.

Water can be contaminated by pesticides in many different ways. Pesticides are applied directly to water for the control of pests such as mosquito larvae, aquatic weeds, and rough fish. Such applications can be made with reasonable environmental safety if the pesticides used are carefully chosen, if they are registered for the intended use, and if they are applied carefully. Water can be grossly contaminated if the wrong pesticide is carelessly applied.

Drift, spills, back-siphoning from sprayers, and poor disposal of containers and surplus pesticides all contribute to direct water contamination. Often the tank filling station for the sprayer is on the bank of a stream or pond, where spills from an overfilled tank can run directly back into the water. **Never** leave a sprayer unattended while the tank is being filled. The tank filler should be equipped with some kind of anti-siphoning device to prevent backward flow of spray materials into the water source. "Empty" pesticide containers that are not completely empty must be accounted for and returned to storage for disposal. Otherwise they and the pesti-

cide inside them are likely to end up in the water. **Never** empty leftover spray down a storm sewer; it is a direct path to water.

Leaching, run-off, and erosion, both by water and wind, are means by which pesticides reach water indirectly. Pesticides frequently bond with soil particles. As long as the soil remains in place, the pesticide remains in place, but poor agricultural practices that lead to erosion lead to pesticide movement into water.

Heavy rains or flooding just after a pesticide application can wash pesticides from the target into water.

Sensitive Areas or Organisms

Sensitive areas are those such as parks, playgrounds, bird sanctuaries, ponds and streams, water supplies, barnyards and feedlots, pastures, bee yards, schools, homes, or any other areas where out-of-place pesticides might cause damage. Be sure you do not expose and pollute these areas when applying pesticides nearby.

Water. Water of any kind represents a sensitive area. Be very careful not to contaminate it, no matter what it is used for.

Honeybees. Honeybees and other pollinators are necessary for good farming and food production. When there is no pollination, there often is no crop. Unfortunately, bees, as well as many of the predators and parasites that help control harmful insects, are very sensitive to many pesticides. Avoid application of pesticides if bees or other helpful insects are likely to be in the area. And, whenever possible, select pesticides that are effective but that are the least toxic to these forms.

Wildlife. Wildlife such as fish, birds, and mammals are assets to humans. Land that is used only as farmland does not have to be a wildlife refuge, but take care to protect surrounding wooded areas and waterways when applying any pesticide.

Barnyards, Feedlots, and Pastures. Farm animals that drink or graze in barnyards, feedlots, and pastures have been killed outright by eating contaminated feed or forage or by drinking contaminated water. Meat and milk have been made unsaleable because the residues from careless pesticide exposure exceeded allowable tolerances.

Schools, Playgrounds, Homegrounds, and Parks. Schools, playgrounds, homegrounds, parks, and other such areas always require special caution. Pet dishes, sandboxes, playground equipment, toys, etc., can receive dangerous amounts of off-target pesticides. When you must use pesticides in or around such areas, choose the safest ones available.

Benefits of Careful Use

Pesticides are an aid to the environment when they are used carefully and wisely. Even in sensitive areas, the careful choice and expert application of a pesticide may do little harm to the environment. When properly used, pesticides can help in the production of better quality and higher yields of food by reducing the damage caused by insects, diseases, weeds, etc. With better yields, more land is left free for recreation and wildlife. Pesticides can increase our enjoyment of recreation areas through the control of annoying pests. They can improve the quantity and quality of livestock products. And they can control runaway epidemics of newly introduced insects and diseases.

Advantages and disadvantages must be carefully weighed. Always choose the pesticide that will do the least damage to nontarget organisms while giving good control, and always consider your operational plans — timing, method of application, formulation, etc. — carefully.

Pesticide misuse and the effects on nontarget organisms can lead to bad publicity for pesticides and pesticide programs and may result in the cancelling of the registration of valuable pesticide tools.

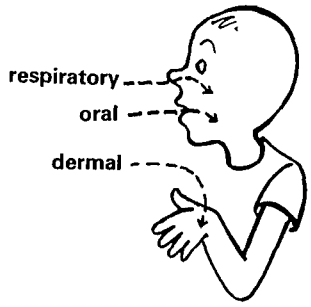
Toxicity and Safety

A principle to remember is that any substance can be toxic if enough of it reaches a place in the body where it can cause some damage or malfunction. Water can be toxic if enough of it enters the lungs: it's called drowning. Common table salt is a chemical, sodium chloride, that the body needs, but it can be lethal if too much enters the digestive tract. To understand toxicity, you must consider the chemistry of the compound, the amount, the time of exposure, and the routes of entry into the body.

There is a difference between toxicity and a hazard. Toxicity is an inherent quality of a substance, the capability that substance has of causing certain undesirable things to happen to an organism. It can be measured. A hazard is the probability of certain undesirable things happening to an organism in a particular situation or at a certain level of exposure.

Before a substance can cause damage, it must get into the body. The modes of entry for pesticides are:

1. **Oral:** entry through the mouth and into the digestive tract.
2. **Dermal:** entry through the skin and then into the circulatory or nervous system.
3. **Respiratory:** entry as particles, droplets, or fumes into the lungs and then into the circulatory system.



A substance must also get into the body in sufficient quantity to be toxic. Toxicity is measured in terms of dose and time. The most commonly used method of designating the toxic dose is expressed as LD/50 or LC/50. LD stands for lethal dose, LC stands for lethal concentration, and the 50 stands for 50 percent of the test population.

An LD/50 usually is given as oral or dermal. Respiratory toxicity usually is given as LC/50. The species and often the sex of the test animal are also given. To be meaningful, the LD/50 must indicate the test animal, the route of administration, and whether the effect was acute or chronic (time factor).

Since LD/50 means lethal dose for 50 percent of the test population, we must assume that it represents an approximation, or average, of the effect of the com-

Table 7. Acute oral and dermal toxicity ranges

Toxicity categories	Acute oral LD/50	Acute dermal LD/50
Highly toxic	Less than 50 milligrams/kilogram	Less than 200 milligrams/kilogram
Moderately toxic	50-500	200-2,000
Slightly hazardous	500-5,000	2,000-20,000
Relatively nonhazardous	Over 5,000	Over 20,000

pound. Further, since a limited number of species of lab animals are used, great care must be used in applying such findings to humans. They should be used in a relative way for general guidance only.

The LD/50 usually is expressed in milligrams of the toxicant per kilograms of body weight of the test animal (mg/kg). If pesticide A has an acute oral LD/50 to female white rats of 42 milligrams/kilogram, it means that a concentration of 42 milligrams of technical grade A fed to each kilogram of body weight of a large number of female white rats killed half of them within a prescribed length of time (usually a few hours).

The thing to remember when examining toxicity tables in which LD/50's are listed is that the **smaller the number, the greater the toxicity** (see table 7).

The key to personal safety when using pesticides is to remember that they can enter your body through your mouth, skin, or lungs. If you can block those entry ways, you won't be hurt. The warnings on the label and information from toxicity tables will tell you if a pesticide is particularly hazardous (when it can be absorbed through the skin, for example) so you can take special precautions.

Avoid, as much as possible, **all** contact with a pesticide. Use common sense: Be sure to wash your hands before eating, work upwind of dust and fumes, and avoid splashing and spills. For some pesticides, you will be advised to use protective clothing and devices such as gloves, a respirator, or impermeable clothing and rubber boots. Be sure you know how to use protective equipment and clothing properly.

If a pesticide accident occurs, it's more important to get medical attention immediately than it is to worry about first aid and waste time. First of all, eliminate the contact with the pesticide. If a concentrate has been spilled on someone's clothing, get the clothing off and wash the skin. If a person is overcome by fumes, get him out into fresh air.

Unfortunately, most of the symptoms of pesticide poisoning can be confused with those of other illnesses. Just because a person gets sick while or after working with pesticides doesn't necessarily mean the pesticides made him ill. However, you should assume the pesticides **may** be responsible and obtain medical assistance.

Some of the symptoms usually associated with pesticide overexposure are: headache, tremors, dizziness, sweating, blurred vision, cramps, shortness of breath, drooling and salivation, rapid heart beat, tightness in chest, diarrhea, loss of muscle control, excitation, depression, and unconsciousness.

In addition, localized effects such as skin irritation, watering eyes, coughing, or temporary nausea may occur in some individuals with some pesticides. The skin irritation caused by some chemicals can be debilitating and painful, although it is not lethal.

When obtaining medical assistance after a pesticide accident, **be sure** to have the label from the container or the **complete correct name** of the pesticide involved.

Storage and Disposal

Almost all pesticide poisoning resulting from accidental ingestion involves children, pets, and livestock. This fact is an indication of wholly inadequate storage and disposal techniques.

All pesticides should be stored in their original containers with labels intact in a secure place where children, unauthorized persons, and animals cannot enter. In most instances, this means in a locked storage room or cabinet. **Never** put pesticides in other containers like pop bottles, feed bags, or open buckets. And **never** store pesticides with livestock feed, minerals, or other feed supplements. Be sure the storage area is high and dry.

Some liquid formulations should not be frozen. If your storage area is not heated, make other safe storage provisions for such pesticides during the winter months.

Excess or unusable pesticides and empty containers must also be handled and disposed of in a safe manner. To avoid the problem to some extent, calculate your needs carefully so you mix up just enough for the job. The best way to get rid of a pesticide is to use it for a legal, registered purpose. If you have a single container of a pesticide, you may take it to the nearest sanitary land fill or to an area where surface or subsurface waters will not be affected.

If you have a large amount of a pesticide you can no longer use, check first with your dealer to see if he or his suppliers will take it back. If not, keep it in safe storage until the appropriate agencies develop and announce a disposal policy. Such a policy will involve incineration in approved incinerators or burial in approved land fills.

Containers

"Empty" containers should be treated carefully also. For metal cans and drums, follow the rinse and drain procedure and any other directions given on the labels. Then puncture, crush, and dispose of them in an approved landfill or recycle them to a drum reconditioner. **Do not** use pesticide containers for food, feed, water, or other purposes.

Protective Clothing and Other Safety Devices

Because pesticides can enter your body through various routes, it is essential that you wear a protective barrier of clothing. No safety recommendations cover all situations; use common sense and remember that you need more protective clothing and devices as the hazard increases. **Always read the pesticide label for recommendations about the use of protective clothing or devices.**

Gloves. Wear liquidproof gloves (such as rubber or neoprene) when handling concentrated or highly toxic pesticides. Do not use gloves lined with fabric, since fabrics are difficult to clean once contaminated. Never use cotton or leather gloves; they will absorb pesticides and they do not provide adequate protection. Your sleeves should be **outside** your gloves to prevent pesticides from getting inside.

Body covering. Wear a long sleeved shirt and long legged trousers or a coverall type garment (all of closely woven fabric) when handling pesticides. Wear your trousers **outside** your boots to prevent pesticides from getting inside. When handling pesticide concentrates or very toxic materials, wear a lightweight raincoat or rubber apron for added protection.

Hat. Wear a wide-brimmed, waterproof hat to protect your neck as well as your eyes, mouth, and face. Your hat should not have a cloth or leather sweatband, since these bands are difficult to clean once contaminated.

Boots. Wear lightweight rubber boots when handling or spraying pesticides. Both leather and canvas boots absorb chemicals and are difficult to clean.

Goggles or face shield. Wear goggles or a face shield when there is a risk of

pesticides coming in contact with your eyes. Your eyes will not only absorb many pesticides, but your vision may be affected. You can wear goggles separately or in combination with a respirator.

Care of Clothing and Devices

Wear a laundered set of clothing daily. If your clothes become wet during the day, change them. Do not store or launder contaminated clothing with the family laundry. Wash your gloves and boots daily. Test your gloves for leaks each day by filling them with water and gently squeezing them.

Wash your goggles or face shield at least daily. Since fabric headbands often absorb pesticides and are difficult to clean, keep several spares on hand so you can replace them periodically.

Respiratory Protective Devices

The respiratory tract is much more absorbent than the skin, so it is essential that you wear an approved respiratory device when there is any risk of inhaling toxic pesticides. **Always follow carefully any instructions given on the label regarding respiratory protection.** Exposure to pesticides for long periods, working with highly toxic pesticides, and working in enclosed areas usually will necessitate wearing some type of respirator.

Chemical Cartridge Respirators. With this type of device, inhaled air usually is drawn through a bed of activated charcoal and through a dust filter. Harmful vapors, gases, and particulate matter are removed. These half-face masks cover the mouth and nose but not the eyes. You can wear goggles in combination with a cartridge respirator for increased protection.

Chemical Canister Respirators or Gas Masks. Gas mask canisters contain more absorbing material and more filters with longer lives than do cartridge respirators. Wear such a respirator when formulating toxic pesticides or when applying them in close or inadequately ventilated spaces. Gas masks usually give greater protection to the face than cartridge respirators. Note, however, that where there may be a deficiency in oxygen, as in a silo, a chemical respirator will not provide adequate protection.

Care and Maintenance

Because specific types of cartridges and canisters protect against specific chemical gases and vapors, it is essential that you use a type designed for protection against pesticides. It also is essential that the respirator fits your face properly to insure a good seal. Excessively long sideburns, a beard, or glasses may prevent an adequate seal.

In chemical cartridge respirators, change the filters twice a day or more often if breathing becomes difficult. Change cartridges after 8 hours of use, or more often if you detect the odor of pesticides. Remove filters and cartridges after each use. Also, wash the face piece with soap and water, rinse it, dry it with a clean cloth, and store it in a clean dry place away from pesticides.

Several factors affect the service life of respiratory protective devices: the type and amount of chemical fill in a cartridge or canister, the concentration of contaminants in the air, the breathing rate of the wearer, and the temperature and humidity. It is essential that you read carefully the manufacturer's instructions on the use and maintenance of any respirator and its parts before using it. Use only respirators approved by the National Institute for Occupational Safety and Health, the U.S. Bureau of Mines, or the U.S. Department of Agriculture.

Remember that wearing a respirator does **not** eliminate the need for wearing protective clothing on other parts of your body.

Laws and Regulations

You should be aware of some of the most important laws that control the use of pesticides. If you use a pesticide in a manner contrary to state and federal laws, you can be fined or even imprisoned.

Federal Laws, Regulations, and Agencies

Federal Insecticide, Fungicide and Rodenticide Act as amended: (1) Provides for registration, labeling, and classification of pesticides. (2) Requires that restricted use pesticides be used only by certified applicators. (3) Makes it illegal to use any pesticide in a manner contrary to the directions on its label.

Food, Drug and Cosmetic Act as amended: (1) Provides for establishment of tolerances for pesticide residues remaining in or on agricultural commodities. (2) Makes it illegal to sell in interstate commerce any food that is adulterated or contaminated, including food contaminated by rodents or insects or other "filth."

Department of Transportation: Controls shipment of classified poisons.

Federal Trade Commission: Controls certain aspects of advertising of pesticides.

U.S. Department of Agriculture Meat and Poultry Inspection Program: Monitors and checks the quality of meat and poultry, including contamination by pesticides.

State Laws, Regulations, and Agencies

Minnesota Pollution Control Agency: (1) Controls and regulates the disposal of containers and excess pesticides. (2) Controls the discharge of hazardous materials into the environment. (3) Controls the burning of trash.

Minnesota Department of Natural Resources: Regulates the use of pesticides in aquatic environments.

Minnesota Department of Agriculture: (1) Registers pesticides sold in the state. (2) Licenses commercial pesticide applicators. (3) Certifies pesticide applicators to use restricted pesticides. (4) Licenses dealers to sell restricted pesticides. (5) Enforces the State Weed Law. (6) Enforces the State Plant Pest Act.

Minnesota State Livestock Sanitary Board: Enforces certain animal health regulations, including those involving some parasites, such as cattle scab.

Minnesota Department of Health: Coordinates poison information centers in Minnesota.

Glossary

The definitions given below serve as a reference for using the terms as they pertain to pesticides.

Abscission: The formation of a layer of cells that results in fruit, leaf, or stem drop from a plant.

Absorption: The uptake of substances by the skin, respiratory tract, and gastrointestinal tract. Also refers to the uptake of substances by plant parts or organs.

Acaricide: A pesticide used to control mites and ticks. Same as miticide.

Acid equivalent: The theoretical yield of parent acid from an ester or salt, such as esters of 2,4-D or the amine salt of 2,4-D.

Activator: A material added to a pesticide to increase, either directly or indirectly, its toxicity.

Active ingredient: The chemical or chemicals in a product responsible for the desired effects. The active ingredient is capable, in itself, of preventing, destroying, or repelling insects, fungi, rodents, weeds, or other pests or of mitigating the damage they cause.

Acute toxicity: Ability to cause injury or death from a single or limited exposure.

Adherence: The property of a substance to adhere or stick to a given surface.

Adjuvant: Any component of a formulation that modifies the mixture beneficially.

Adsorption: The process by which materials are held or bound to the surface in such a manner that the chemical is only slowly available. In many instances, clay and high organic soils tend to adsorb pesticides.

Adulterated: By law, applied to any pesticide if its strength or purity falls below the professed standard or quality as expressed on its labeling or under which it is sold, or if any substance has been substituted wholly or in part for the article, or if any valuable constituent of the article has been wholly or partially abstracted. May also apply to illegal residues in food.

Aerobic: Living or functioning in air or free oxygen. The opposite of anaerobic.

Aerosol: An extremely fine mist produced when the pesticide dissolved in a liquid gas is released into the air from a pressurized container.

Alkaloid: Naturally occurring nitrogenous materials appearing in some plants that are used in preparing the botanically-derived insecticides.

Amphibians: Animals of the class vertebrata that are intermediate between fish and reptiles. They are cold-blooded with nucleated red blood cells. They have a moist skin without scales, feathers, or hair.

Anaerobic: Living or functioning in the absence of air or free oxygen. The opposite of aerobic.

Animal sign: The evidences, distinctive for a particular species, that are left, indicating an animal's presence in an area.

Anionic surfactant: A surface-active additive to a pesticide having a negative surface charge. The anionics perform better in cold, soft water. Most wetting agents are of this class.

Annual: A plant that completes its life cycle from seed to seed in 1 year.

Antagonism: The phenomenon that results in a depression of activity of an organism or compound when two or more occur close together.

Antibiotic: Substance, usually produced by a microorganism, that is injurious to other microorganisms (streptomycin, cycloheximide, etc.).

Anticoagulant: A substance that prevents normal blood-clotting.

Antidote: A practical treatment, including first aid, used in treatment of poisoning.

Aquatic weeds: Undesirable plants that grow in water.

Aqueous: Indicating the presence of water in a solution. A solution of a chemical in water.

Arsenicals: Inorganic pesticides containing arsenic.

Aseptic: Free of disease-causing organisms.

Attractants: Substances or devices capable of attracting insects or other pests to areas where they can be trapped or killed.

Avicide: Any chemical used to kill birds.

Bactericide: Any chemical used to kill bacteria.

Bait shyness: The tendency for rodents, birds, or other pests to avoid a poisoned bait.

Band application: An application to a continuous restricted area such as in or along a crop row rather than over the entire field area.

Basal treatment: A treatment applied to the stems or trunks of plants at and just above the ground line.

Biennial: A plant that completes its life cycle in 2 years. The first year it produces leaves and stores food. The second year it produces fruits and seeds.

Biocide: A chemical that has a wide range of toxic properties, usually to both plants and animals.

Biological control: Control of pests by means of predators, parasites, and disease-producing organisms.

Birds: Animals of the class vertebrata that differ from their ancestral reptiles by having a covering of feathers. They have a warm-blooded metabolism, and the forelimbs are modified into wings.

Botanical pesticide: A pesticide produced by and extracted from plants. Examples are nicotine, pyrethrum, strychnine, and rotenone.

Brand: The name, number, trademark, or designation of a pesticide or device made by the manufacturer, distributor, importer, or vendor. Each pesticide that differs in the ingredient statement, analysis, manufacturer or distributor, name, number, or trademark is considered a distinct and separate brand.

Broadcast application: An application over an entire area.

Broadleaf species: Botanically, those plants classified as dicotyledons; morphologically, those plants having broad, rounded, or flattened leaves as opposed to the narrow blade-like leaves of the grasses, sedges, rushes, and onions.

Brush control: Control of woody plants.

Carcinogen: A substance or agent capable of producing cancer.

Carcinogenic: The term used to describe the cancer-producing property of a substance or agent.

Carrier: The liquid or solid material added to a chemical compound to prepare a proper formulation.

Causal organism: The organism (pathogen) that produces a given disease.

Centigrade (C): A thermometer scale in which water freezes at 0 degrees and boils at 100 degrees. To change to degrees Fahrenheit, multiply degrees centigrade by nine-fifths and add 32.

Chemical name: One that indicates the chemical composition of the compound.

Chemosterilant: A chemical compound capable of producing reproductive sterilization.

Chemotherapy: The treatment of a desired plant or animal with chemicals to destroy or control a pathogen without seriously harming the plant.

Chlorinated hydrocarbon: A chemical compound containing chlorine, carbon, and hydrogen. Chlordane is a chlorinated hydrocarbon.

Chlorosis: The yellowing of a plant's normally green tissue because of a partial failure of the chlorophyll to develop.

Cholinesterase: A chemical catalyst (enzyme) found in animals that helps limit the activity of nerve impulses. Some pesticides, phosphates, and carbamates, for example, can inhibit this enzyme and are called cholinesterase inhibitors.

Chronic toxicity: Ability to cause injury or death from prolonged exposure.

Common pesticide name: A name given to a pesticide by a recognized committee. Many pesticides are known by a number of trade or brand names but have only one recognized common name. Example: the common name for Karathane, Arathane, Iscothane, and Mildex is dinocap.

Compatible: Two compounds are said to be compatible when they can be mixed without affecting each other's properties.

Concentration: The amount of active ingredient in a given volume or weight of diluent.

Contact herbicide: A compound that kills primarily by contact with plant tissue rather than as a result of translocation. Only that portion of a plant contacted is directly affected.

Contact insecticide: A compound that causes the death of an insect when it touches its external parts. It does not need to be ingested to be effective.

Crucifers: Plants belonging to the mustard family, including mustard, cabbage, turnips, radish, etc.

Cucurbits: Plants belonging to the gourd family, including pumpkins, cucumbers, squash, etc.

Deciduous plants: Those plants that are perennial in habit but lose their leaves during the winter.

Deflocculating agent: A material added to a suspension to prevent settling.

Defoliant: A compound that causes the leaves or foliage to drop from a plant.

Degradation: The process by which a chemical compound is reduced to a less complex compound.

Dermal: Of or pertaining to the skin.

Dermal toxicity: Ability of a compound to produce symptoms of poisoning when absorbed through the skin of animals.

Desiccant: A compound that promotes drying or removal of moisture from plant tissues. (See defoliant for difference between these two terms.)

Diluent: Any liquid or solid material used to dilute or carry an active ingredient.

Dip treatment: The application of a liquid chemical to a plant by momentarily immersing it, wholly or partially, under the surface of the liquid to coat the plant with the chemical.

Directed application: An application to a restricted area such as a row or bed or at the base of plants.

Dispersing agent: A material that reduces the cohesive attraction between like particles. Dispersing and suspending agents are added during the preparation of wettable powders to facilitate wetting and suspension of the active ingredient.

Dormant: State of inhibited growth of seeds or other plant organs due to internal causes.

Dose, dosage: Quantity of a toxicant applied per unit of plant, soil, or other surfaces.

Drench treatment: The application of a liquid chemical to an area until the area is completely soaked.

Emulsifiable concentrate: A formulation produced by dissolving the active ingredient and an emulsifying agent in a solvent. When added to water, an emulsion (milky mixture) is formed.

Emulsifying agent: A material that facilitates the suspending of one liquid in another.

Emulsion: A mixture in which one liquid is suspended as minute globules within another liquid; e.g., oil in water.

Eradicant: A chemical used to eliminate a pest from a plant or a place in the environment. (See also chemotherapy.)

Eradication: The complete elimination of weeds, insects, disease organisms, or other pests from an area.

Fahrenheit (F): A thermometer scale that marks the freezing point of water at 32° F and the boiling point at 212° F. (See also centigrade.)

Fish: Animals of the class vertebrata that are cold-blooded. They are confined to a strictly aquatic environment, breathing by means of gills.

Fog treatment: The application of a pesticide as a fine mist for the control of pests.

Formulation: The pesticide product containing the active ingredient, the carrier, and other additives required to make it ready for sale.

Fumigant: A chemical that forms vapors (gases) and is used to destroy weeds, plant pathogens, insects, or other pests.

Fungi: All nonchlorophyll-bearing thallophytes. For example: rusts, smuts, mildews, and molds. (The singular form or fungi is fungus.)

Fungicide: A chemical that kills or inhibits fungi.

Fungistatic: A chemical that inhibits the germination of fungus spores or the development of mycelium while in continued contact with the fungus.

Granule: A type of formulation in which the active ingredient is mixed with, adsorbed, absorbed, or pressed on an inert carrier, forming a small pellet.

GPM: Gallons per minute.

Growth regulator: A substance effective in minute amounts for modifying plant processes. (See plant growth regulator for a broader definition.)

Growth stages of cereal crops: (1) Tillering -- when additional shoots are developing from the lower buds. (2) Jointing -- when stem internodes begin elongating rapidly. (3) Booting -- when upper leaf sheath swells due to the growth of a developing spike or panicle. (4) Heading — when seed head is emerging from the upper sheath.

Hard (water): Water containing soluble salts of calcium and magnesium and sometimes iron.

Hazard: The probability that injury will result from use of a substance in a proposed quantity and manner. The sum of the toxicity plus the exposure to a pesticide.

Herbaceous plant: A vascular plant that does not develop woody tissue.

Herbicide: A pesticide used for killing or inhibiting plant growth. A weed or grass killer.

Hydrogen-ion concentration: A measure of the acidity. The hydrogen-ion concentration is expressed in terms of the pH of the solution. For example, a pH of 7 is neutral, from 1 to 7 is acid, and from 7 to 14 is alkaline.

Impermeable: Not capable of being penetrated. Semipermeable means permeable to some substances but not to others.

Inert ingredient: Ingredients in a product that do not contribute to the activity of the active ingredient.

In-furrow treatment: The application of a chemical in a furrow.

Ingredients: The simplest constituents of the pesticide that can reasonably be determined and reported. Ingredients may be active or inert.

Insect: Any of the numerous small invertebrate animals generally having segmented bodies and for the most part belonging to the class insecta, comprising six-legged, usually winged forms.

Insecticide: A substance or mixture of substances intended to prevent or destroy any insects that may be present in any environment.

Label: All written, printed, or graphic matter on, attached to, or accompanying the pesticide or its immediate container.

Lactation: The period during which an animal is producing milk.

LC50: The concentration of a compound that is expected to cause death in 50 percent of the test animals so treated. A means of expressing the toxicity of a compound present in air as dust, mist, gas, or vapor. It is generally expressed as micrograms per liter as a dust or mist, but, in the case of a gas or vapor, it is expressed as parts per million.

LD50: By law, the dose that is expected to cause death within 14 days in 50 percent of the test animals so treated. If a compound has an LD50 of 10 milligrams/kilogram, it is more toxic than one having an LD50 of 100 milligrams/kilogram.

Leaching: Movement of a substance downward or out of the soil in or with water as the result of water movement.

Low volatile ester: An ester with a high molecular weight and a low vapor pressure capable of changing from a liquid to a gas.

Mammals: Animals of the class vertebrata that are warm-blooded and nourish their young with milk. The skin is more or less covered with hair.

Metamorphosis: Any change in form or structure of an insect during the growing period.

Miscible liquids: Two or more liquids capable of being mixed and remaining mixed under normal conditions.

Molluscicide: A chemical that kills slugs and snails.

Mutagenic: Capable of producing genetic change.

Necrosis: Localized death of living tissue; i.e., death of a certain area of a leaf or of a certain area of an organ.

Necrotic: A term used to describe tissues exhibiting varying degrees of dead areas or spots.

Nematicide: A material that will kill nematodes. (Nematicide is more acceptable than nematocide.)

Nonselective: A chemical that is generally toxic to plants or animals without regard to species. A nonselective herbicide may kill or harm all plants.

Noxious Weed: A plant defined by law as being especially undesirable, troublesome, and difficult to control.

Oral toxicity: Ability to cause injury when taken by mouth.

Organic compounds: A large group of chemical compounds that contain carbon. See also organochlorine and organophosphate.

Organochlorine: Same as chlorinated hydrocarbon.

Organophosphate: An organic compound containing phosphorus; parathion and malathion are two examples.

Ovicide: A substance that destroys eggs.

Pathogen: Any disease-producing organism or virus.

Perennial: A plant that lives for more than 2 years.

Pests: Forms of plant and animal life or viruses that exist under circumstances that make them injurious to plants, humans, domestic and other animals, articles, or substances.

Pesticide: A chemical substance used to kill pests. The pests may be weeds, insects, rats and mice, algae, nematodes, and other destructive forms of life.

Phytotoxic: Injurious to plants.

Plant growth regulator: A substance that alters the growth of plants. The term does not include substances intended solely for use as plant nutrients or fertilizers.

Postemergence: After the appearance of a specified weed or crop.

PPB: Parts per billion. A way of expressing amounts of chemicals in foods, plants, animals, etc. One part per billion equals 1 pound in 500,000 tons.

PPM: Parts per million. A way of expressing amounts of chemicals in foods, plants, animals, etc. One part per million equals 1 pound in 500 tons.

Predator: An animal that preys on, destroys, or devours other animals. Even though most animals prey on smaller forms, this term is usually restricted to members of the carnivora (dog, cat, weasel, etc., families) plus a few meat eaters, such as opossums and seals, from other mammalian groups. Raptorial birds (hawks, owls, and eagles) are included, as are some fish eaters like herons and kingfishers. Some fish and reptiles may also be included.

Preemergence: Prior to emergence of the specified weed or crop.

Preplant: Application of a pesticide prior to planting a crop.

Propellant: Agent in self-pressurized pesticide products that produces the force required to dispense the active ingredient from the container.

Protectant: A chemical applied to the plant or animal surface in advance of the pest (or pathogen) to prevent infection or injury by the pest.

PSI: Pounds per square inch.

Pubescent: Hairy. Hairiness affects ease of wetting of foilage and retention of spray on foliage.

Repellent: A compound that is annoying to a certain animal or other organism, causing it to avoid the area in which it is placed.

Reptiles: Animals of the class vertebrata that are air-breathing and cold-blooded. They lack hair or feathers on their skin, which is more or less covered with horny epidermal plates or scales.

Residue: The amount of chemical that remains on the harvested crop.

Rhizome: Underground root-like stem that produces roots and leafy shoots. Examples: the white underground parts of Johnsongrass and horsenettle; the black parts of Russian knapweed.

Rodent: All animals of the order rodentia, including rats, mice, gophers, woodchucks, and squirrels.

Rodenticide: A substance or mixture of substances intended to destroy or repel rodents or to prevent or mitigate the damage they do.

RPM: Revolutions per minute.

Safener: A material added to a pesticide to eliminate or reduce phytotoxic effects to certain species.

Seed protectant: A chemical applied to seed before planting to prevent disease and insect attack of seeds and new seedlings.

Selective pesticide: A chemical that is more toxic to some species (plant, insect, animal, microorganisms) than to others.

Slurry: A thick suspension of slightly soluble to insoluble pesticides in a liquid medium (with water usually being the main liquid). Particles will settle out of a slurry fairly rapidly if it is left standing and if it is not kept under agitation. See suspension.

Soil application: Application of a chemical to the soil rather than to vegetation.

Soil incorporation: Mechanical mixing of a pesticide with the soil.

Soil injection: Mechanical placement of a pesticide beneath the soil surface with a minimum of mixing or stirring. Common method of applying liquids that change into gases.

Soil sterilant: A chemical that prevents the growth of plants, microorganisms, etc., when present in soil. Soil sterilization may be temporary or relatively permanent, depending on the nature of the chemical being applied.

Solution: Mixture of one or more substances in another in which all the ingredients are truly and completely dissolved in the molecular state.

Solvent: A liquid that will dissolve a substance, forming a true solution (liquid in molecular dispersion).

Spot treatment: The application of a pesticide to selected individual plants, animals, or soils.

Spray drift: The movement of airborne spray particles away from the intended application area.

Spreader: A substance that increases the area that a given volume of liquid will cover on a solid or on another liquid.

Sticker: A material added to a pesticide to increase its persistence or adherence rather than to increase the initial deposit.

Stolon: Aboveground runners or slender stems that develop roots, shoots, and new plants at the tip of nodes, as in the strawberry plant or Bermuda grass.

Stomach poison: A pesticide that must be eaten by an insect or other animal in order to kill the animal.

Supplement: Same as adjuvant. Substance added to a pesticide to improve its physical or chemical properties. May be a sticker, spreader, wetting agent, safener, etc., but usually is not a diluent.

Surfactant: A material that increases the emulsifying, dispersing, spreading, wetting, or other surface-modifying properties of a pesticide formulation.

Susceptible species: A plant or animal that is affected by moderate amounts of a pesticide.

Suspension: A system consisting of very finely divided solid particles dispersed in a liquid.

Synergism: The joint action of two or more pesticides that is greater than the sum of the pesticides when used alone.

Systemic pesticide: A chemical that is translocated within the plant. For example, a systemic insecticide can be applied to the soil, enter the roots of the plant, travel to the leaves, and kill insects feeding on the leaves.

Tolerance: By law, a regulation that establishes the maximum amount of a pesticide chemical that may remain on the raw agricultural commodity.

Tolerant: The ability of a living organism to withstand, to a degree, a disease, insect attack, dry weather, etc.

Toxicant: Any poison or poisonous substance. In a herbicide or insecticide, for example, the active ingredient is the toxicant. However, the active ingredient in a plant growth regulator may not poison the plant and therefore is not a toxicant. All active ingredient compounds are not toxicants.

Toxicity: The natural capacity of a substance to produce injury. Toxicity is measured by oral, dermal, and inhalation studies on test animals.

Trade name: Same as brand name.

Translocated pesticide: One that is moved within the plant from the site of entry. Systemic pesticides are translocated.

ULV: Ultra low volume. No water is applied with the pesticide formulation.

Vapor drift: The movement of vapors of a volatile chemical from the area of application.

Vapor pressure: The property that causes a chemical compound to evaporate. The lower the vapor pressure, the more volatile is the compound.

Vector: A carrier such as an insect that carries and transmits a pathogen. For example, some virus diseases of plants can only be carried by certain insects.

Vertebrate animals: A major category of animals that are distinctive by their possession of a segmented spinal column.

Viscosity: A property of liquids that determines whether they flow readily or resist flow. Viscosity of liquids usually increases with a decrease in temperature.

Volatile: A compound is said to be volatile when it evaporates (changes from a liquid to a gas) at ordinary temperature upon exposure to air.

Weed: A plant that is undesirable due to certain characteristics or due to its presence in certain areas. A plant growing in a place where it is not wanted.

Wettable powder: A solid (powder) formulation which, upon addition to water, forms a suspension used for spraying. It is prepared by adding water soluble agents to the formulation.

Wetting agent: A compound that reduces surface tension and causes a liquid to contact plant surfaces more thoroughly.

Winter annual: A plant that germinates in the fall and completes its life cycle by early summer.

Zero tolerance: By law, no detectable amount of pesticide may remain on raw agricultural commodities when they are offered for shipment. Zero tolerances are no longer allowed.