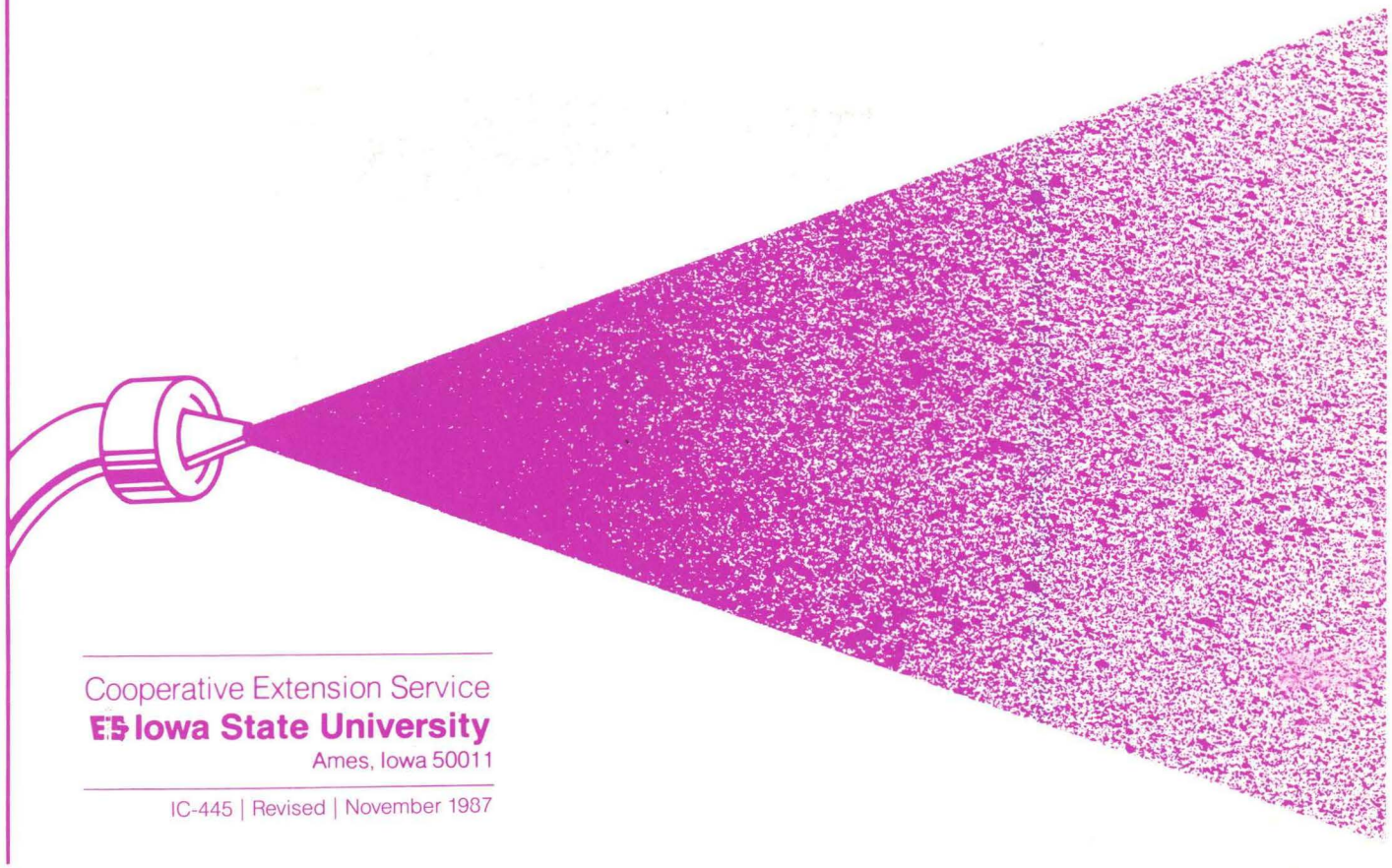
The Iowa Core Manual

A Guide for Commercial Pesticide Applicators



Cooperative Extension Service
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and justice for all
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INTRODUCTION

Iowa law requires that anyone who applies restricted use pesticides on their own property or anyone who applies pesticides for hire must be certified as a Pesticide Applicator.

Private Pesticide Applicators are persons who apply any restricted use pesticide for the production of an agricultural commodity on property owned or rented by themselves or their employers, or on the property of another person with whom they trade services. An individual employed by a farmer who applies pesticides as an incidental part of the individual's general duties or an individual who applies a restricted use pesticide as an incidental part of a custom farming operation is required to be certified as a private pesticide applicator. Private pesticide applicators must pass an examination as of 1987 to become initially certified.

Commercial Pesticide Applicators are persons who apply pesticides or utilize pest controlling devices for hire on property other than their own. Commercial pesticide applicators must pass an examination over the Iowa Core Manual and each applicable category manual to obtain certification.

Public Pesticide Applicators are persons who apply pesticides as an employee of a state agency, county, or municipal corporation, or any other governmental agency. Public applicators must pass an examination over the Iowa Core Manual and each applicable Category manual to obtain certification.

The Iowa Core Manual is intended to provide you with the information you need to pass the Core Manual examination. This guide covers:

- how pesticides work;
- how to use pesticides so they will not harm individuals or the environment;
- how pesticide labels can help the applicator;
- signs and symptoms of pesticide poisoning;
- the most common features of pests, how they develop, and the kinds of damage they do;
- methods to control pests and how to combine these methods for the best results;
- how to choose, use, and care for pesticide application equipment; and
- the federal and state laws that apply to pesticide use.

This manual was prepared by Iowa State University Extension staff members: Wendy Wintersteen, entomology associate; Laura Sweets, plant pathologist; and Dick Fawcett, weed scientist. Special thanks to Sally Pease and Julie Honeick for their help in manual preparation.

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Understanding Pesticides

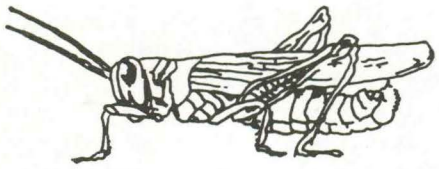
Types of Pesticides

A pesticide may be defined as "any chemical used to destroy, prevent, or control pests. Although the ending, "cide", is derived from the Latin word cida, meaning "to kill", not all pesticides actually kill the target organism. For example, some fungicides may simply inhibit the growth of a fungus without killing it; attractants and repellents serve only to lure a pest to or divert it from a particular site.

It is important to realize that there is no way that one can generalize about pesticides. Each is different and must be judged on the basis of its chemical composition and its labeled uses. We cannot conclude from a problem that might occur with one pesticide that others will have the same problem.

Here are the types and uses of pesticides.

Insecticides are chemicals used to control insects and other related animals, such as ticks, spiders, centipedes and mites. Often the word "insecticide" is confused with the word "pesticide"; however, it is just one of many types of pesticides.



Microbial insecticides are naturally occurring insect-disease microorganisms that are lethal to a specific group of insects. These microorganisms can be bacteria, viruses, protozoans, or fungi.

Insect growth regulators are laboratory-synthesized hormones of insects. They can interfere with the normal growth pattern of insects by affecting the molting process or the change from the immature stage to the adult.

Herbicides are chemical used to control unwanted plants.

Fungicides are chemicals used to kill or inhibit fungi that cause rots, leaf spots, blights, mildews, rusts, or other plant diseases.

Nematicides are chemicals used to control nematodes that cause certain plant diseases.

Bactericides are chemicals used to prevent bacteria that cause certain plant diseases.

Rodenticides are chemicals used to control rats, mice and other rodents.

Fumigants are gases designed to kill insects and other organisms in a confined space. They are hazardous because of the danger of accidental poisoning to humans and other animals and also because of the flammability of certain gases.

Avicides are chemicals used to control birds. Other types of pesticides are used to control specific pests: "piscicides" control fish, "miticides" control mites, and "molluscides" control snails and slugs.

Attractants can be used to lure insects to traps or insecticides. The attractants may stimulate feeding,

mating, oviposition (egg-laying) responses within the insects. "Pheromones" are insect hormones that act as attractants.

Repellents divert insects from crops, animals, or structures. Most repellents work through vapor action as well as through direct contact.

Plant-growth regulators change the normal growth or reproduction of a plant. Some growth regulators are used to move up or move back the normal harvest date for the crop.

Harvest-aids are chemicals used to harvest crops more efficiently. They are classified as "defoliants" and "desiccants."

How Pesticides Work

Pesticides can be grouped according to how they control pests. Many pesticides will work in more than one way. Read the label to find out what each pesticide will do.

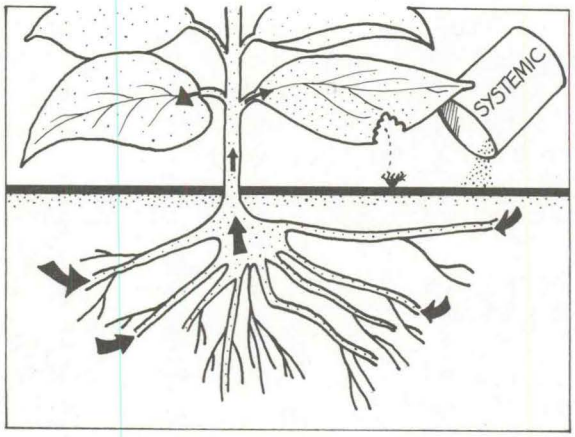
Selective pesticides are effective against a limited group of pests (for example, broadleaf weeds), as opposed to **nonselective** pesticides which are not discriminating and control nearly all related organisms. For example, a nonselective herbicide is used where all vegetation is undesirable.

Residual or persistent pesticides remain active in amounts sufficient to kill pests for at least a week, perhaps several weeks or even years after application. **Nonresidual or nonpersistent pesticides** break down rapidly after application. For example, residual insecticides are useful when insects are a continual problem, for example with termites in wooden structures.

Stomach poisons are chemicals taken orally by an animal so that the poison enters the stomach and then is absorbed into the body.

Contact pesticides control the pest upon contact. Contact pesticide are applied to the surface of a plant, animal, or structure. The pest is killed upon coming in contact with the pesticide.

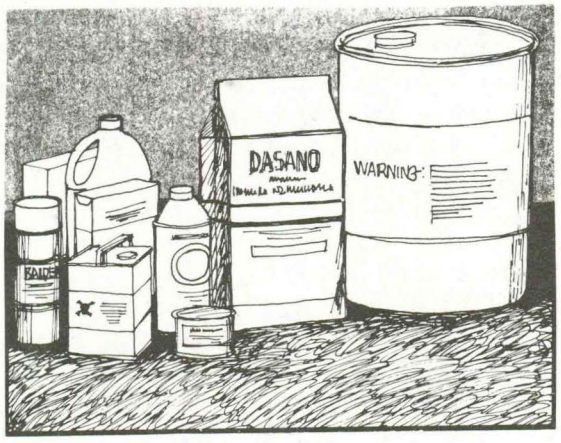
Systemic or translocated pesticides are absorbed by the treated plant or animal, and moves from the site of absorption to other tissues. For example, systemic fungicides are absorbed by the plant and move through the living tissues without harming the plant. Because of this capability, systemic fungicides can be used either as protectants to prevent penetration by the fungus, or to kill the fungus even after it has become established within the plant tissue.



Types of Formulations

Active ingredients are the chemicals in a pesticide product that do the work. Active ingredients can rarely be used in the form in which they were made. They usually must be changed or mixed with something else. Other ingredients may be added to make them convenient to handle and safe, easy, and accurate to apply. These are the inert ingredients. This mixture of active and inert ingredients is called a **pesticide formulation.** Some formulations are ready for use but others must be

diluted with water or a petroleum solvent.



A single active ingredient often is sold in several different kinds of formulations. You must choose the formulation that will be best for each use. In making your choice, consider:

* the plant, animal, or surface to be protected (some formulations may be phytotoxic, absorbed by the animal, pitting or marring surface),
* application machinery available and best suited for the job,
* hazard of drift and runoff (nearness to sensitive areas, likelihood of wind or rain),
* safety to applicator, and other humans and pets likely to be exposed,
* habits or growth patterns of the pest (bait vs. broadcast spray, granular vs. foliar spray),
* cost
* type of environment in which the application must be made (agricultural, aquatic, forest, urban, etc.)

Emulsifiable Concentrates (EC or E)

An emulsifiable concentrate formulation usually contains the active ingredient, one or more petroleum solvents, and an emulsifier which allows the formulation to be mixed with water. Each gallon of EC usually contains two to eight pounds of active ingredient. EC's are among the most versatile formulations. They are used against agriculture, ornamental and turf, forestry, structural, food processing, livestock, and public health pests. They are adaptable to many types of application equipment, from small, portable sprayers to hydraulic sprayers, low-volume ground sprayers, mist blowers, and low-volume aircraft sprayers.

Advantages:
* High concentration means price per pound of active ingredient is relatively low and product is easy to handle, transport, and store,
* Little agitation required; not abrasive; will not settle out or separate when equipment is running,
* Little visible residue on fresh fruits and vegetables and on finished surfaces.

Disadvantages:
* High concentration makes it easy to overdose or underdose through mixing or calibration errors,
* Phytotoxicity hazard usually greater,
* Easily absorbed through skin of humans or animals,
* Solvents may cause rubber or plastic hoses, gaskets, and pump parts and surfaces to deteriorate,
* May cause pitting or discoloration of painted finished,
* May be corrosive.

Solutions (S)

A few pesticide active ingredients dissolve readily in water. Formulations of these pesticides contain the active ingredient and one or more additives. When mixed with water, they form a solution which will not settle out or separate. Solutions may be used in any type of sprayer indoors or outdoors.

Advantages:
* No agitation necessary.

Disadvantages:
* Very few formulations of this type available.

Ultra Low Volume Concentrate Solutions (ULV)

ULV concentrate solutions contain eight or more pounds of active ingredient per gallon. They may approach 100 percent active ingredient. ULV concentrates are designed to be used as is or to be diluted with only small quantities of specified solvents. These special-purpose formulations must be applied with highly specialized spray equipment. They are mostly used in outdoor applications such as in agricultural, forestry, ornamental, and mosquito control programs. The advantages and disadvantages are similar to those for emulsifiable concentrates.

Low Concentrate Solutions (S)

These formulations, usually solutions in petroleum solvents, contain small amounts (usually one percent or less) of active ingredient per gallon. They are designed to be used without further dilution. Low concentrate solutions are used for:
* structural and institutional pests,
* clothes moths,
* livestock and poultry pests,
* space sprays in barns and warehouses,
* mosquito control.

Advantages:
* No mixing necessary,
* Household formulations have no unpleasant odor; do not stain fabric.

Disadvantages:
* Expensive,
* Limited number of uses.

FLOWABLES (F OR L)

Some active ingredients are insoluble solids. These may be formulated as flowables in which the finely ground active ingredients are mixed with a liquid, along with inert ingredients, to form a suspension. Flowables are mixed with water for application and are similar to EC formulations in ease of handling and use. They are used in the same type of pest control operations for which EC's are used.

Advantages:
* Seldom clog nozzles,
* Easy to handle and apply.

Disadvantages:
* Require moderate agitation,
* May leave a visible residue.

AEROSOLS

These formulations contain one or more active ingredients and a solvent. Most aerosols contain a low percentage of active ingredient. There are two types of aerosol formulations--the ready-to-use type, and those made for use in smoke or fog generators.

Ready-to-use aerosols are usually small, self-contained units which release the pesticide when the nozzle valve is triggered. The pesticide is driven through a fine opening by an inert gas under pressure, creating fine droplets. These products are used in greenhouses, in small areas inside buildings, or in localized outdoor areas. Commercial models hold 5 to 10 pounds of pesticide, and these are usually refillable.

Advantages:
* Ready to use,
* Easily stored,
* Convenient way of buying small amount of a pesticide,
* Retain their potency over fairly long time.

Disadvantages:
* Expensive
* Practical for very limited uses,
* Risk of inhalation injury,
* Hazardous if punctured, overheated, or used near an open flame,

* Difficult to confine to target site or pets.

Formulations for smoke or fog generators are not under pressure. They are used in machines which break the liquid formulation into a fine mist or fog (aerosol) using a rapidly whirling disk or heated surface. These formulations are used mainly for insect control in structures such as greenhouses and warehouses and for mosquito and biting fly control outdoors.

Advantages:
* Easy method of filling entire space with pesticide.

Disadvantages:
* Highly specialized use,
* Fairly expensive for pounds of active ingredient per gallon,
* Difficult to confine to target or pest,
* Risk of inhalation injury.

Invert Emulsions

This unusual mixture contains a water-soluble pesticide dispersed in an oil carrier. Invert emulsions require a special kind of emulsifier that allows the pesticide to be mixed with a large volume of petroleum carrier, usually fuel oil. When applied, invert emulsions form large droplets which do not drift easily. Invert emulsions are most commonly used in vegetation control along right-of-ways where drift to susceptible nontarget plants is a problem.

Fumigants

Fumigants are pesticides which form poisonous gases when applied. Sometimes the active ingredients are gases which become liquids when packaged under high pressure. These formulations become gases which released during application. Other active ingredients are volatile liquids when enclosed in an ordinary container and so are not formulated under pressure. They become gases during application. Others are solids that release gases when applied under conditions of high humidity or in the presence of water vapor.

Fumigants are used for structural pest control, in food and grain storage facilities, and in regulatory pest control at ports of entry and at state and national borders. In agricultural pest control, fumigants are used in soil and in greenhouses, granaries, and grain bins.

Advantages:
* Toxic to a wide range of pests,
* Can penetrate cracks, crevices, wood, and tightly packed areas such as soil or grains,
* Single treatment will usually kill most pests in treated area.

Disadvantages:
* The target area must be enclosed or covered to prevent the gas from escaping,
* Highly toxic to humans--specialized protective equipment, including respirators, must be used with fumigants.

Dusts (D)

Most dust formulations are ready to use and contain a low percentage of active ingredient (usually 1 to 10 percent), plus a very fine dry inert carrier made from talc, chalk, clay, nut hulls, or volcanic ash. The size of individual dust particles is variable.

Dust concentrates contain a greater percentage of active ingredient. These must be mixed with dry inert carriers before they can be applied.

Dusts are always used dry and easily drift into nontarget areas. They sometimes are used for agricultural applicants. In structures, dust formulations are used in cracks and crevices and for spot treatments. They are widely used in seed treatment. Dusts are also used

to control lice, fleas, and other parasites on pets and domestic animals and poultry.

Advantages:
* Usually ready to use, with no mixing,
* Effective where moisture from a spray might cause damage,
* Require simple equipment,
* Effective in hard-to-reach indoor areas.

Disadvantages:
* Drift hazard high,
* Expensive because of low percentage of active ingredient.

Granules (G)

Granular formulations are similar to dust formulations except that granular particles are larger and heavier. The coarse particles are made from an absorptive material such as clay, corn cobs, or walnut shells. The active ingredient either coats the outside of the granules or is absorbed into them. The amount of active ingredient is relatively low, usually ranging from 1 to 15 percent.

Granular pesticides are most often used to apply chemicals to the soil to control weeds, nematodes, and insects living in the soil. They also may be used as systemics--formulations that are applied to the soil, then absorbed into the plant through the roots and carried throughout the plant. They are sometimes used in airplane or helicopter applications because drift is minimal. Granular formulations are also used to control larval mosquitoes and other aquatic pests. Granules are used in agricultural, ornamental, turf, aquatic, right-of-way, and public health (biting insect) pest control operations.

Advantages:
* Ready to use; no mixing,
* Drift hazard is low--particles settle quickly,
* Low hazard to applicator--no spray, little dust,
* Weight carries the formulation through foliage to soil target,
* Simple application equipment--often seeders or fertilizer spreaders,
* May be more persistent than WP's or EC's.

Disadvantages:
* Does not stick to foliage,
* More expensive than WP's or EC's,
* May need to be incorporated into soil,
* May need moisture to activate pesticidal action.

Pellets (P or PS)

Pellet formulations are very similar to granular formulations; the terms often are used interchangeably. A pellet, however, is a formulation manufactured to create a pellet of specific weight and shape. The uniformity of the particles allows them to be applied by precision applicators such as those being used for precision planting of pelleted seed.

Wettable Powders (WP or W)

Wettable powders are dry, finely ground formulations which look like dusts. They usually must be mixed with water for application as a spray. A few products, however, may be applied either as a dust or as a wettable powder--the choice is left to the applicator. Wettable powders contain 5 to 95 percent active ingredient, usually 50 percent or more. Wettable powders do not dissolve in water. They settle out quickly unless constant agitation is used to keep them suspended.

Wettable powders are one of the most widely used pesticide formulations. They can be used for most pest problems and in most types of spray machinery where agitation is possible.

Advantages:
* Low cost,

* Easy to store, transport, and handle,
* Lower phytotoxicity hazard than EC's and other liquid formulations,
* Easily measured and mixed,
* Less skin and eye absorption than EC's and other liquid formulations.

Disadvantages:
* Inhalation hazard to applicator while pouring and mixing the concentrated powder,
* Require good and constant agitation (usually mechanical) in the spray tank,
* Abrasive to many pumps and nozzles, causing them to wear out quickly,
* Residues may be visible.

Soluble Powders (S)

Soluble powder formulations look like wettable powders. However, when mixed with water, soluble powders dissolve readily and form a true solution. After they are thoroughly mixed, no additional agitation is necessary. The active ingredient in soluble powders ranges from 15 to 95 percent, usually over 50 percent.

Soluble powders have all the advantages of the wettable powders and none of the disadvantages, except the inhalation hazard during mixing. Few pesticides are available in this formulation because few active ingredients are soluble in water.

Microencapsulation

Microencapsulated formulations are particles of pesticides (either liquid or dry) surrounded by a plastic coating. The formulated product is mixed with water and applied as a spray. Once applied, the capsule slowly releases the pesticide. The encapsulation process can prolong the active life of the pesticide by providing a timed release of the active ingredient.

Advantages:
* Increased safety to applicator,
* Easy to mix, handle, and apply.

Disadvantages:
* Constant agitation necessary in tank,
* Some bees may pick up the capsules and carry them back to the hives where the released pesticide may poison the entire hives.

Water-Dispersible Granules (Dry Flowables)

Water-dispersible granular formulations are like wettable powder formulations, except the active ingredient is prepared as granule-sized particles. Water-dispersible granules must be mixed with water to be applied. The formulation requires constant agitation to keep it suspended in water. Water-dispersible granules share the advantages and disadvantages of wettable powders except:
* They are more easily measured and mixed,
* They cause less inhalation hazard to the applicator during pouring and mixing.

Adjuvants

An adjuvant is an inert material added to a pesticide formulation or tank mix to increase the effectiveness of the active ingredient. Most pesticide formulations contain at least a small percentage of additives. Some applicators add additional adjuvants while mixing for special applications. Some product labels may caution against adding adjuvants.

* **Wetting agents** allow wettable powders to mix with water and stick on plant or animal surfaces.
* **Emulsifiers** allow petroleum-based pesticides (ECs) to mix with water.
* **Spreaders** allow pesticide to form a uniform coating layer over the treated surface.
* **Stickers** allow pesticide to adhere to the treated surface for a longer period of time.
* **Penetrants** allow the pesticide to

get through the outer surface to the inside of the treated area.

* **Foaming agents** reduce drift.
* **Thickeners** reduce drift by increasing droplet size.
* **Safeners** reduce phytotoxicity of pesticide to protected crop.
* **Compatibility agents** aid in combining pesticides effectively.
* **Buffers** allow mixing of pesticides of different acidity or alkalinity.
* **Anti-foaming agents** reduce foaming of spray mixtures that require vigorous agitation.

COMPATIBILITY

Two or more pesticides that can be mixed together to control a wider range of pests with a single application are said to be compatible with each other. Sometimes the pesticides are formulated together by the manufacturer but the applicator often must mix separate formulations in the tank. It is important to remember that not all pesticides work well in combination. Pesticides that are not compatible can result in loss of effectiveness against the target pests, injury to the treated surface (phytotoxicity in plants, toxicity in treated animals, stains, or corrosion on treated surfaces), or separation of ingredients into layers or setting out of solids.

The first step in determining compatibility is to read the label. You cannot mix two pesticides if the label on either one of the products states that the product should not be used with other chemicals. The label will not always indicate, however, whether the product can be mixed with other chemicals. In these cases, check compatibility by a "jar test." Place one pint of carrier (usually water or liquid fertilizer) in a quart jar, and add the appropriate amount of pesticide in the proper sequence: WP's first, L's or F's second, and EC's third. Shake 5 to 10 seconds after each addition. Allow the mixture to stand for 10 to 15 minutes. If incompatibility occurs in any form (flakes, sludge, jell, precipitate, etc.), the mixture should not be tank mixed. Some incompatible mixture may be made compatible with the addition of commercial compatibility agents.

To minimize compatibility problems with tank mixes, follow the correct mixing procedures. The usual method for tank-mixing pesticides is to fill the tank at least one-half to two-thirds full before adding any pesticide or adjuvant. If a compatibility agent is necessary, always add it before adding the pesticides. The order of adding various formulations should be as follows: WP's first, L's or F's second, WDG's or DF's third, and EC's, S's, and surfactants last. Each product must be well mixed before the next is added. When more than one pesticide is mixed in fluid fertilizer, premix each in water before adding it to the fertilizer.

To make sure that you have a uniform spray mixture at all times, keep the mixture agitated during application, and do not allow it to stand overnight without agitation. If possible, apply all of a tank mixture in one day.

FACTORS AFFECTING PESTICIDE ACTIVITY

SOIL FACTORS

Organic matter in soils limits pesticide activity. Soils with high organic matter content may need higher rates of pesticides for good pest control. Follow label instructions.

Soil texture also affects the way pesticides work. Soils with fine particles (silts and clays) provide the most surface area. They may need higher rates. Coarser soils (sands) have less surface area. Use lower rates on them. Follow label instructions.

Soil moisture and rain affect the way pesticides work and how long pesticides stay on soil and plants. Pesticides work best with moderate soil moisture. Wetness may keep the pesticide from contacting the soil particles and rain causes soluble pesticides to leach down through the soil. Rain is good when preemergence pesticides are applied to the surface because it may wash pesticides off the leaves.

Humidity and temperature also affect the way pesticides work. Herbicides work best when plants are growing fast. High relative humidity and optimum temperatures usually cause this fast growth. High temperatures cause some soil pesticides to evaporate quickly. Low temperatures may slow down or stop the activity of some pesticides.

Light may break down some pesticides if they are left on the soil surface for a long time.

Pesticide Resistance

The ability of pests to resist poisoning must be considered when planning pest control programs that rely on the use of pesticides.

Rarely does any pesticide kill all the target pests. Each time a pesticide is used, it selectively kills the most sensitive pests. Some pests avoid the pesticide while others are able to withstand its effects. Pests that are not destroyed pass along to their offspring the trait that allowed them to survive.

When one pesticide is used repeatedly in the same place, the pest population sometimes builds up its resistance. Some pests have become practically immune to poisoning by certain pesticides.

Not every pesticide failure is caused by pest resistance, however. There must be the correct pesticide, the correct dosage, and the correct application.

Pesticide Labels

The pesticide label is the information printed on or attached to the container of pesticides. This label means many things. To the manufacturer, it is a "license to sell." To the state or federal government, it is a way to control the distribution, storage, sale, use, and disposal of the products. To the buyer or user, it is the source of facts on how to use the product correctly and legally. It is a way to tell users about special measures needed.

Pesticide Properties

The information contained on the pesticide label is based on scientific research conducted to provide this information in order to register a pesticide. Information on physical and chemical properties, toxicological profile, residue analysis and exposure estimates from projected uses, as well as product efficacy, must be submitted to EPA.

Physical and Chemical Properties

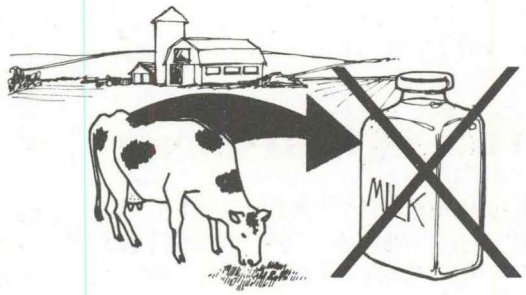
The properties of the pesticide include solubility in water and other solvents, volatility (tendency to vaporize), stability to heat and light, and other factors that affect how the material will act in the environment. These parameters help experts to estimate whether the pesticide can accumulate in the fat of humans and animals, whether it is susceptible to vaporization after application, whether it will be tied up in the soil after application, and whether it will leach in certain soils.

Toxicological Profile

Toxicity tests must be performed on rats and rabbits, and certain fish and birds. The tests include acute oral, dermal and inhalation toxicity to various species; reproductive, teratogenic (ability to produce birth defects), mutagenic (ability to produce genetic change), and oncogenic (ability to produce tumors) effects. These tests must be performed for several dose levels of each pesticide.

Residue Analyses

The amount of pesticide remaining in a plant at harvest or in an animal at slaughter is called a residue. Because pesticides degrade at different rates in different tissues, studies must be conducted on each plant part or animal product intended for consumption.



Exposure Estimates

Applicator exposure is estimated for the intended use of each pesticide. Exposure of consumers through residues in foods is also estimated, based on the average amount eaten per year of each type of food on which the pesticide is to be used.

NOEL, a No Observable Effect Level, is determined in the toxicological tests on animals described above. The NOEL is the highest dosage at which no ill effects were seen in the study.

MSF, a Minimum Safety Factor, is then applied to the NOEL. The MSF is based on a fraction of the NOEL, so the end result is that humans will be

exposed to only a fraction of the amount observed to cause no adverse health effects in animal studies. An MSF of 100 or 1/100 of the NOEL, is the usual case.

Tolerances

A residue tolerance is simply the legal amount of residue allowable in or on a raw agricultural commodity. Tolerances are specific for each pesticide and crop or animal and are established by EPA. They are based in part on the variety of foods on which a pesticide is to be used, the NOEL, and the MSF. Tolerances are expressed in parts per million (ppm), that is, parts of the pesticide per million parts of plant or animal tissue. In most foods, the tolerance ranges from 0.05 to 10 ppm. One ppm is a very small quantity. For example, 1 ppm is 1 ounce of salt in 62,000 pounds of sugar or 1 pound of pesticide in 1 million pounds of apples. It is now possible for an analytical chemist, using the appropriate equipment and techniques, to detect some pesticides at levels approaching 1/1000 of one part in a million parts, which is one part per billion (ppb). The Federal Food and Drug Administration (FDA) regularly inspects and analyzes samples of fruits, vegetables, feeds, dairy products, meat and other produce to be certain there is no excessive pesticide residue on food.

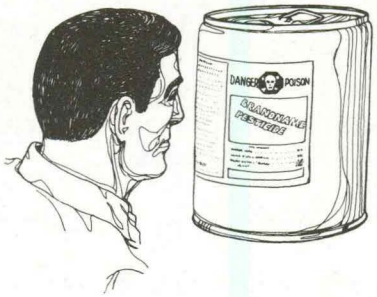
Remember that the tolerance is the highest amount of residue legally allowable. When applied in accordance with label directions, the residue should not exceed, and often is significantly lower than, the tolerance. Washing and scrubbing fruit and vegetables and various food processing procedures such as peeling and cooking can further reduce the amount of residue remaining on food prior to consumption.

Parts of the Label

Pesticide labels conform to a set of standards established by federal law. Each label must contain the following information.

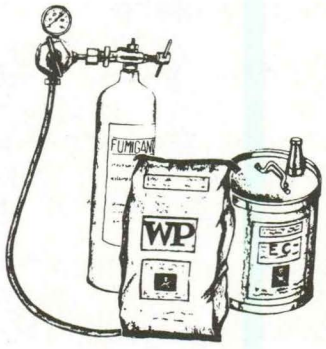
Brand Name

The brand name is the one used in ads. The brand name shows up plainly on the front panel of the label and is the most identifiable name for the product.



Type of Formulation

Different types of pesticide formulations (such as liquids, wettable powders, and dusts) require different methods of handling. The label tells what type of formulation the package contains. The same pesticide may be available in more than one formulation.



Common Name

Many pesticides have complex chemical names. Some have been given a common name to make them easier to identify. For instance, carbaryl is the common name for 1-naphthyl N-

methylcarbamate. A chemical made by more than one company will be sold under several brand names, but you should find the same common name or chemical name on all of them.

Ingredient Statement

Every pesticide label must list what is in the product, written so that you can quickly see what the active ingredients are. The amount of each active ingredient is given as a percentage by weight or as pounds per gallon of concentrate. It can be listed by either the chemical name or the common name. The inert ingredients need not be named, but the label must show what percent of the contents they include.

Net Contents

Net contents number tells how much is in the container. It can be expressed in gallons, pints, pounds, quarts, or other units of measure.

Name and Address of Manufacturer

The law requires the manufacturer of a product to put the name and address of the company on the label.

Registration and Establishment Numbers

A registration number must be on every pesticide label showing that the product has been registered with the federal government. It usually is found on the front panel of the label and will be written as "EPA Registration No. 0000." The establishment number tells what factory made the chemical. This number does not have to be on the label, but will be somewhere on each container.

Signal Words and Symbols

To do their job, most pesticides must control the target pest. By their nature, they are toxic. Therefore, some may be hazardous to people. You can tell the toxicity of a product by reading the signal word and looking at the symbol on the label. The hazard categories have been determined by considering the acutely toxic effects of the pesticides when they are swallowed, inhaled, spilled on the skin; effects on the eyes and external injury to the skin are also considered.

***Danger/Poison** and a skull-and-crossbones symbol must appear on the labels of all products that are highly toxic orally, dermally, or by inhalation. If the product is corrosive to eyes or skin, but is not considered highly toxic, only the signal word **Danger** is required. Ingesting as little as a taste to one teaspoonful of one of these pesticides could kill an average adult.


ACTIVE INGREDIENT: Methomyl
S-methyl-N-[(methylcarbamoyl)oxy]thioacetimidate 24%
INERT INGREDIENTS 76%
U.S. Pats. 3,576,834 & 3,639,633 EPA Reg. No. 352-370-AA

Keep out of reach of children

DANGER ☠ POISON

FLAMMABLE. CONTAINS METHANOL.
MAY BE FATAL OR CAUSE BLINDNESS IF SWALLOWED.
POISONOUS IF INHALED. CAUSES EYE DAMAGE.

Do not breathe vapors or spray mist. Keep away from heat, sparks, and open flame.
Do not get in eyes, on skin, on clothing. Use with adequate ventilation. Keep container closed.
In case of contact, wash skin with plenty of soap and water. for eyes, flush with water for 15 minutes and get medical attention. remove and wash contaminated clothing before re-use.

ANTIDOTE AND FIRST AID

ATROPINE IS AN ANTIDOTE—CONSULT PHYSICIAN FOR EMERGENCY SUPPLY OF 1/100 GRAIN ATROPINE TABLETS. CALL A PHYSICIAN AT ONCE IN ALL CASES OF SUSPECTED POISONING.

If swallowed, give a tablespoonful of salt in a glass of warm water and repeat until vomit fluid is clear. If inhaled, remove from exposure. Have patient lie down and keep quiet. If patient is not breathing, use artificial respiration immediately. Never give anything by mouth to an unconscious person.

If warning symptoms appear (See warning symptoms below), before physician arrives, immediately swallow two atropine tablets (each 1/100 gr.); thereafter, every 10 to 15 minutes, take one atropine tablet

***Warning** is the signal word required on the labels of all products that are moderately toxic orally, dermally, or by inhalation, or that cause moderate eye and skin irritation. A teaspoonful to a tablespoonful by mouth could kill an average adult.


Warning:

Keep out of reach of children. May be fatal if swallowed. May be absorbed through skin. Do not breathe spray mist. Do not get in eyes, on skin or on cothing. Wash thoroughly after handling. Avoid contamination of food and feed. Keep out of reach of domestic animals. Do not use on humans, household pets, or livestock. Do not permit children or pets to go onto the sprayed grass until spray has completely dried.

Fish and Wildlife Caution: This product is toxic to fish and wildlife. Birds feeding

***Caution** is the signal word required on the labels of all products considered slightly toxic to

relatively nontoxic orally, dermally or by inhalation, or that cause slight eye and skin irritation. An average adult could be killed by ingesting an ounce to more than a pint of one of these pesticides.

All labels must bear the statement, "Keep out of reach of children."

Table 1. Toxicity Categories

Measure of Toxicity	I Highly Toxic	II Moderately Toxic	III Slightly Toxic	IV Relatively Nontoxic
Oral LD_{50} (mg/kg)	0-50	50-500	500-5,000	>5,000
Dermal LD_{50} (mg/kg)	0-200	200-2,000	2,000-20,000	>20,000
Inhalation LC_{50} (ug/l)	0-200	200-2,000	2,000-20,000	>20,000
Lethal Dose, 150 lb person	**Few drops to 1 tsp.**	**1 tsp. to 1 oz. (2 TBSP)**	**1 oz. to 1 pint+**	**1 pint+**
Eye Effects	Corrosive	Irritation for 7 Days	Irritation for <7 days	None
Skin Effects	Corrosive	Severe Irritation	Moderate Irritation	Mild Irritation
Signal Word/Symbol	**DANGER-POISON/ Skull and Crossbones**	**WARNING**	**CAUTION**	**CAUTION**

Precautionary Statement

Hazards to Humans (and Domestic Animals)

This section explains the ways in which the product may be poisonous to man and animals. It also tells of any special steps to take to avoid poisoning, such as the kind of protective equipment needed. For example, the precautionary statement may direct you to use rubber gloves, an approved respirator, or goggles when working with the pesticide.

If the product is highly toxic, this section will inform physicians of the proper treatment for poisoning.

Environmental Hazards

Pesticides are useful tools but wrong or careless use could cause undesirable effects. To help avoid this, the label contains environmental precautions to read and follow. For example:

* "This product is highly toxic to bees exposed to direct treatment or to residues on crops."
* "Do not contaminate water when cleaning equipment or when disposing of wastes."
* "Do not apply where runoff is likely to occur."

Labels may contain broader warnings against harming birds, fish, and wildlife.

Physical and Chemical Hazards

This section tells of any special fire, explosion, or chemical hazards that the product may pose.

Statement of Practical Treatment

If swallowing or inhaling the product or getting it in the eyes or on the skin would be harmful, the label tells emergency first aid measures. It also tells what types of exposure require medical attention.

The pesticide label is the most important information to take to the physician when someone has been poisoned.

Statement of Use Classification

Every pesticide label must show whether the contents are for general use or restricted use. EPA puts every product use into one of these two classes. The classification is based on the hazard of poisoning, the way the pesticide is used, and its effect on the environment.

General Use

If a pesticide will harm the applicator or the environment very little or not at all when used exactly as directed, it will be labeled a general use pesticide, and the label says: "General classification."

Restricted Use

A restricted use pesticide is one that could cause some human injury or environmental damage even when used as directed on the label. The label on these products says: "Restricted use pesticide for retail sale to and application only by certified applicators or persons under their direct supervision."

In Iowa, **only** certified applicators may apply restricted use pesticides.

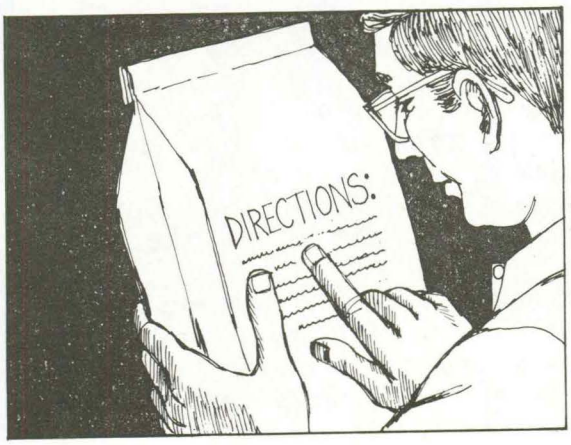
The restricted use statement must be at the top of the front panel of the label.

Directions for Use

The instructions on how to use the pesticides are an important part of the label. This is the best way to find out the right way to apply the product.

The use instructions tell:

* the pests the product is registered to control (Labels use common names for pests. Knowing these names will help to choose the proper pesticide and find control information);
* the crop, animal, or other item the product can be used on;
* whether the product is for general or restricted use;
* in what form the product should be applied;
* how much to use;
* where the material should be applied;
* when it should be applied.



Misuse Statement

This section reminds you that it is a violation of federal law to use a product in a manner inconsistent with its labeling. Do not use a product on a crop not listed on the label. Do not use it at more than the recommended rate. Before the product could be registered, EPA required the manufacturer to conduct many tests to be sure the label directions were correct. Following them exactly, will give the best results with the product. Since the label is the law, not following label directions is breaking the law.

Reentry Statement

If it is required for the product, this section tells how much time must pass before a pesticide-treated area is safe for entry by a person without protective clothing. The minimum legal protective clothing for early reentry following agricultural and other outdoor treatments is:

* long-sleeved shirt,
* long-legged trousers or coveralls,
* hat,
* sturdy shoes with socks.

Gloves are suggested. For early reentry in enclosed areas, a respirator may be necessary.

The reentry statement may be printed in a box under the heading "Reentry" or it may be in a section with a title such as "Important," "Note," or "General Information."

If no reentry statement appears on the label or if no reentry period is set by your state, then you must wait at least until sprays are dried or dusts have settled before reentering or allowing others to reenter a treated area without protective clothing. That is the minimum legal reentry interval.

Category of Applicator

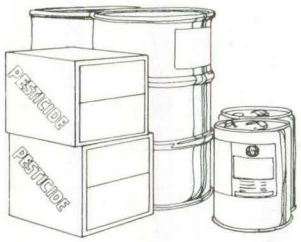
If required for the product, this section will limit use to certain categories of commercial applicators.

Storage and Disposal Directions

Every pesticide should be stored and disposed of correctly. This section will tell how to store the product and then dispose of empty containers. Typical statements include:

* Not for use or storage in or around the home,
* Store away from fertilizers, insecticides, fungicides, and seeds.
* Store at temperatures above 32° F (0° C),

* Do not reuse container,
* Do not contaminate water, food, or feed by storage and disposal,
* Open dumping is prohibited,
* Triple rinse and offer this container for recycling or reconditioning, or dispose in an approved landfill,
* Use excess or dispose in an approved landfill,
* Do not reuse bag.



One or more of these statements may appear on a pesticide label. You should try to determine the best storage and disposal procedure for your operation and location. These statements may appear in a special section of the label titled "Storage and Disposal" or under headings such as "Important", "Note," or "General Instructions."

Label Terminology

Many terms are used on the label to describe when and how to use pesticides. They also are found in leaflets and bulletins that you may get from your local Cooperative Extension agent, land-grant university, or other agencies. Your understanding of the terms will help you get the best results from pesticides.

Terms that tell you **when to use** the pesticide product include:

Preplant - used before the crop is planted.

Preemergence - used before crop or pests emerge. May also refer to use after crops emerge or are established, but before pests emerge.

Postemergence - used after the crop and pests have emerged.

Terms that tell you **how to use** the pesticide product include:

Band - application to a strip over or along a crop row or on or around a structure.

Basal - application to stems or trunks at or just above the ground line.

Broadcast - uniform application to an entire, specific area.

Crack and crevice - application in structures to cracks and crevices where pests may live.

Dip - complete or partial immersion of a plant, animal, or object in a pesticide.

Directed - aiming the pesticide at a portion of a plant, animal, or structure.

Drench - saturating the soil with a pesticide; also, the oral treatment of an animal with a liquid.

Foliar - application to the leaves of plants.

In-furrow - application to the furrow in which a plant is planted.

Over-the-top - application over the top of the growing crop.

Pour-on - pouring the pesticide along the midline of the back of livestock.

Sidedress - application along the side of a crop row.

Soil application - application to the soil rather than to vegetation.

Soil incorporation - use of tillage implements to mix the pesticide with the soil.

Soil injection - application beneath the soil surface.

Spot treatment - application to a small area.

Reading the Label

Before you buy a pesticide, read the label to determine: (1) Whether it is the pesticide you need for the job. Never buy a pesticide simply on the basis of the color of the label or the product name. (2) Whether the pesticide is too hazardous to be used safely under the application conditions.

Before you mix the pesticide, read the label to determine: (1) What protective equipment you should use. (2) What the pesticide can be mixed with (compatibility). (3) How much pesticide to use. (4) The mixing procedure.

Before you apply the pesticide, read the label to determine: (1) What safety measures you should follow. (2) Where the pesticide can be used (livestock, crops, structures, etc.). (3) When to apply the pesticide (including the waiting period for crops and animals). (4) How to apply the pesticide. (5) Whether there are any restrictions for use of the pesticide.

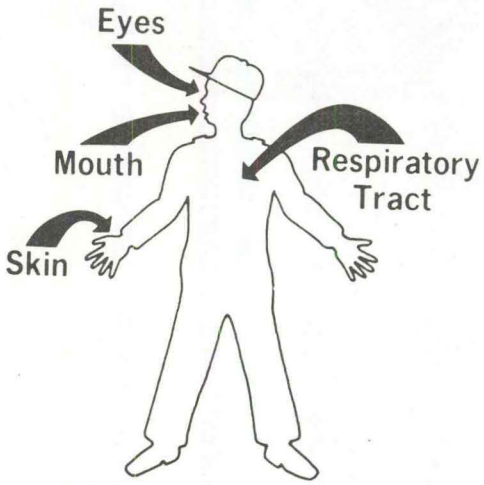
Before you store or dispose of the pesticide or pesticide container, read the label to determine: (1) Where and how to store the pesticide. (2) How to decontaminate and dispose of the pesticide container. (3) Where to dispose of surplus pesticides.

Using Pesticides Safely

Pesticides are toxic. They can cause injury. The product's hazard--the danger that injury will occur to humans--depends on the toxicity of the active ingredient or carrier plus the exposure to the product during use.

How Pesticides Enter the Body

Pesticides may enter the human body through the skin, the mouth, the lungs, and the eyes. Even where the chemical is not absorbed by the body, certain pesticides may cause significant injury to skin and eye tissue.



Many accidental pesticide deaths are caused by eating or drinking the product.

Some mixers, loaders, and applicators are injured or even killed when they breathe a pesticide vapor or get a pesticide on their skin. Repeated exposure to small amounts of some pesticides can cause sudden severe illness.

Most pesticides can enter the body through the skin. More may enter the body this way than through accidental swallowing or inhaling while working with pesticides. With some pesticides, skin contact alone can cause death.

To help prevent **all** accidents with pesticides:

* Use and store pesticides away from children and other untrained persons.
* Take care to follow directions. Products for restricted use need special care. The label is the guide.

Dermal Exposure

Absorption through the skin is the most common route of poisoning of agricultural workers. Absorption may occur as the result of a splash, spill, or drift when mixing, loading, applying, or disposing of pesticides. It may also result from exposure to large amounts of residue on a crop or when cleaning or repairing contaminated equipment.

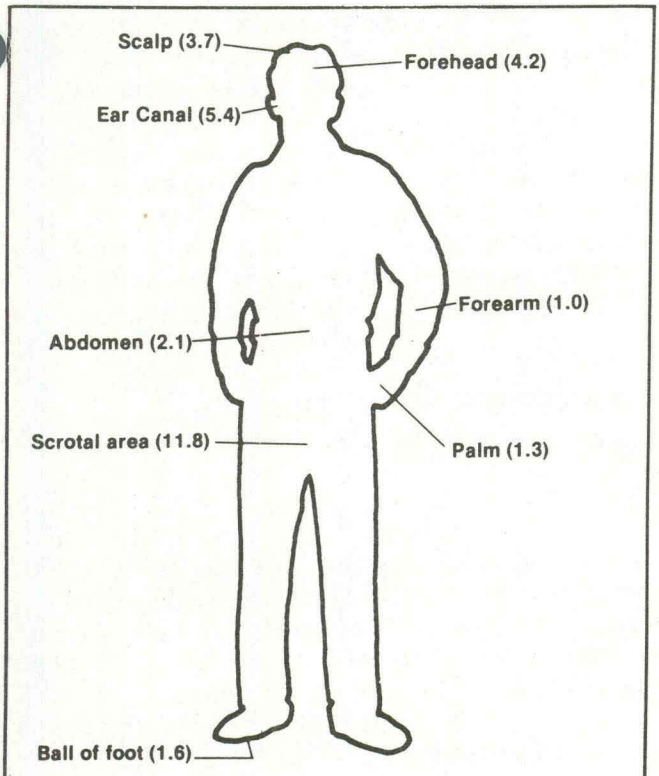
The degree of dermal absorption hazard depends on the dermal toxicity of the pesticide, the extent of the exposure, the way the pesticide is formulated, and the site of contamination. In general, wettable powders, dusts, and granular pesticides are not as readily absorbed through the skin and other body tissues as are liquid formulations such as the emulsifiable concentrates.

Rates of absorption through the skin are different for different parts of the body. Using absorption through the forearm (1.0) as the standard, absorption is over 11 times faster in the lower groin area. Absorption through the skin in the scrotal area is rapid enough to approximate the effect of injecting the pesticide

directly into the bloodstream. At this rate, the absorption of pesticide through the skin into the bloodstream is more dangerous than swallowing it.

You should also be aware that it is not only the pesticide that is dangerous. Many pesticides are carried in oil-based materials. If this oil gets into the bloodstream, the results can be fatal. The oil crosses the skin barrier as rapidly as the pesticide in highly sensitive parts of the body. Wear rubber aprons or rubber trousers to protect the lower parts of the body.

Absorption continues to take place through all of the affected skin area as long as the pesticide is in contact with the skin. The seriousness of the exposure is increased if the contaminated area is large, or if the material remains on the skin for a long period of time.



Dermal absorption rates as compared with the forearm.

If a pesticide is splashed or spilled, wash immediately. It is also important to wash hands thoroughly before smoking, eating, or using the bathroom.

Overexposure to Pesticide Leads to Hospitalization

At planting time, a 42 year old Iowan farmer suffered nausea, headaches, and blurred vision while operating a 12 row planter. He crawled to his pickup, drove home erratically, bathed and was taken to the hospital. For the past three days, he had been loading a corn rootworm insecticide treated with a fungicide into the planter hoppers. On the day of his illness, he had driven through the smoke from burning insecticide bags. He was hospitalized for two days.

Oral Exposure

If a pesticide is swallowed, it may result in serious illness, severe injury, or even death. Pesticides may be consumed by accident, through carelessness, or they may be consumed intentionally. The most frequent cases of accidental oral exposure occur where pesticides have been taken from the original labeled container and put into an unlabeled bottle or food container. Children under 10 are the victims of at least half of the accidental pesticide deaths in this country. If pesticides were always cared for correctly, children would never touch them.

Poisoning as a result of oral exposure to pesticides is almost always due to inexcusable carelessness. Follow these rules:

* Always store a pesticide in its original labeled container.
* Never use the mouth to clear a spray line or nozzle or to begin siphoning a pesticide.
* Never eat, drink, or smoke until after leaving the work area and washing thoroughly.

Child Eats Rootworm Insecticide

A three year old Iowa farm child was playing outside during corn planting time when he discovered a pile of purple granules on the ground. Later the child was found semiconscious clinging to the fence in the front yard. A purple stain on his lips matched the purple granules. At the emergency room, the child was in a stupor with muscle twitchings, pinpoint pupils, frothing at the mouth and bluish skin coloration. The granules were identified as a common corn rootworm insecticide.

Respiratory Exposure

Respiratory exposure is particularly hazardous because pesticides can be rapidly absorbed by the lungs. In addition, pesticides can be inhaled in sufficient amount to cause serious damage to nose, throat, and lung tissue. Vapors and extremely fine particles pose the most serious risks.

The risk of respiratory poisoning is generally low when diluted sprays are applied with conventional application equipment, due primarily to the relatively large droplet sizes produced. When low-volume equipment is being used to apply concentrated material, the risk is increased substantially because of the smaller droplets produced. There is significant risk when mixing and loading dust or powder formulations. Application in confined spaces (e.g. during treatment of stored grain) is particularly hazardous. Protection from respirator exposure is provided by gas masks and other respiratory devices.

Eye Exposure

The tissues of the eye are particularly absorbent. Besides the potential for chemical injury to the eye itself, some pesticides may be absorbed in sufficient amounts through the eye to result in serious or even fatal illness. Eye protection is needed when measuring or mixing pesticide concentrates and when applying highly or moderately toxic materials. Protective shields or goggles should also be used whenever there is a chance that sprays or dusts may come into contact with the eyes. These pieces of protective equipment should be kept available and clean at all times.

It should now be obvious that pesticides can enter the body in solid, liquid, or gaseous form. It is particularly important to remember that highly concentrated and highly toxic chemicals, especially liquids and gases, present the greatest danger. If not removed immediately, most liquid concentrates can readily penetrate the unbroken skin and cause sickness. The longer a pesticide remains on skin or in the eyes, or the longer it is inhaled, the greater the risk that serious damage will occur.

Fate of Pesticides in the Body

Once a pesticide has been absorbed, it eventually enters the bloodstream and can be circulated to body organs. Depending principally on the particular chemical properties of the pesticide and on the dosage, three possibilities exist: metabolism, excretion and accumulation.

Metabolism

Metabolism is the general process of breaking down or building up

compounds for the body to use as it needs them. Although your body cannot use pesticides for food, it does have mechanisms to change many pesticides into different forms, which are often less toxic. Specifically, this process is called detoxification. The liver is especially important in detoxification reactions. A few pesticides, however, are actually made more poisonous after being metabolized.

Excretion

Most pesticides currently in use in the United States are excreted (eliminated) from the body in urine, feces, exhaled air or sweat. Urine is the most common carrier of excreted pesticides, thus, the kidneys are very important. The amount of time necessary for complete elimination of a pesticide from the body varies from a few hours to months.

Accumulation

Some pesticides are not eliminated from the body. Instead, they are deposited in certain tissues, especially the fat, there they may accumulate (concentrate). These pesticides may be found in milk, too, since it contains a high percentage of fats.

Half-Life

The combination of all three of these processes determines the half-life of any particular chemical in the body. The half-life is defined as the amount of time it takes to eliminate 50 percent of the chemical. Generally, the longer it takes to eliminate a pesticide, the greater the chance that it may cause a toxic effect. Repeated exposure to a pesticide with a relative long half-life will result in increasing amounts circulating throughout the body or accumulating in organs or tissues.

Toxicity of Pesticides

Knowing the toxicity of a pesticide means knowing how poisonous it is. The toxicity of a pesticide must be measured in more than one way. Many pesticides are dangerous after one large dose. Some pesticides, however, are dangerous after small, repeated doses.

Measuring Pesticide Toxicity

Determining the toxicity of pesticides to humans is not easy. Obviously humans cannot be test animals. Other animals, usually rats, are used. However, just because a pesticide is very poisonous to rats does not necessarily mean it is also very poisonous to dogs, cows, people, or wildlife. Likewise, a pesticide that is relatively nontoxic to rats is not always safe to other animals. Toxicity studies are only guidelines. They are used to estimate how poisonous a pesticide is compared to another pesticide.

Acute Toxicity

Acute toxicity is how poisonous a pesticide is to an animal (or human) after a single exposure. A pesticide with a high acute toxicity is deadly if even a very small amount is absorbed. Usually poisonous comparisons of pesticides are on the basis of acute toxicity, which is also the basis for the warning statements on the label. Acute toxicity may be measured as acute oral toxicity, acute dermal toxicity, or acute inhalation toxicity.

LD_{50} is a standard toxicological term that means single lethal dose (deadly amount) for 50 percent of a population of test animals, usually rats, mice, or rabbits. LD_{50} values are measured from 0 up and are given as a single oral dose, a single dermal dose, or both. The lower the LD_{50} value, the more toxic the pesticide. Most LD_{50} values are given on a basis of milligrams of pesticide per

kilogram of body weight of test animal. However, most people cannot readily relate to the metric units of weight, milligram and kilogram, and LD_{50} values based on ounces of pesticide per 100 pounds of test animal would be more meaningful. Therefore, in order to convert LD_{50} values given in milligrams per kilogram to values given in ounces per 100 pounds, the value given in milligrams per kilogram should be divided by 625.

For example, malathion has an oral LD_{50} of 1375. This means that if 1375 milligrams of technical or concentrate malathion per kilogram of body weight were fed to each animal of a test population, approximately 50 percent of the animals would be killed as a result.

$$\frac{1375 \text{ mg/kg}}{625 \text{ oz./100 lbs}} = 2.2 \text{ oz.}$$

1375 divided by 625 equals 2.2 oz., the lethal dose for an individual weighing 100 lbs. Therefore, the probable lethal oral dose of technical malathion for a 200-pound human would be 2 times 2.2 or 4.4 ounces. The word "probable" is stressed because toxicological data obtained from specific animal studies do not necessarily apply to humans or other species of animals.

Acute inhalation toxicity is measured by LC_{50}. LC means "lethal concentration." "Concentration" is used instead of "dose" because the amount of pesticide inhaled from air is being measured. LC_{50} values are measured in milligrams per liter. Liters are metric units of volume similar to a quart. The lower the LC_{50} value, the more poisonous the pesticide.

Chronic Toxicity

Chronic toxicity is how poisonous a pesticide is to an animal (or human) after small, repeated doses over a period of time. It is possible to be poisoned without ever getting a large dose of pesticide.

Harmful effects that occur from small doses repeated over a period of time are termed chronic effects. In laboratory tests, and studies of exposed humans, it has been noted that certain pesticides have the ability to cause one or more of these chronic effects. It is important to remember that, as with acute effects, the outcome depends on the dosage, or amount of exposure. Generally, people with chronic illnesses suspected of being caused by a particular pesticide have been exposed to repeated high doses such as might occur during manufacturing or formulation processes.

Types of Chronic Effects

Oncogenicity is the ability of a substance to cause tumors. This is a general term, and the tumors may be either malignant (cancerous) or benign (noncancerous). Carcinogenicity, the more specific term, refers to the ability to cause malignant tumors.

Mutagenicity is the ability of a substance to cause changes in the genetic composition of a cell. If this occurs in an egg or sperm cell, the change, or defect, may be passed on to offspring.

Neurotoxicity indicates toxic effects to the nervous system. Such damage might result in loss of memory or coordination, headaches or muscular weakness.

Reproductive effects. Several types of reproductive effects may occur from exposure to specific compounds. They include the ability to cause birth defects; to cause changes in the amount of activity of sperm; and to cause toxic effects to the fetus, such as spontaneous abortions (miscarriages) or babies of low birth weight.

Dermatologic Effects

Dermatitis, or inflammation of the skin, is generally accepted as the most commonly reported effect associated with pesticide exposure. Individuals very greatly in their susceptibility to dermatologic effects.

Many substances can cause dermatitis on contact. Symptoms range from a slight redness of the skin to blisters or ulcerated lesions. Factors that affect the extent of such irritation include the chemical properties of the substance, the duration and level of exposure, condition of the skin, temperature and humidity, and location of the contact. Remember that the face, scalp, neck and groin absorb substances rapidly, whereas the palms of the hands and soles of the feet resist absorption.

Pesticides able to cause primary irritant dermatitis include certain dithiocarbamates, organophosphates, carbamates, nitrophenols, organochlorines and others. The labels of these pesticides will indicate that they can cause irritation if label precautions are not followed.

Symptoms of Pesticide Poisoning

It is important to know what kinds of sickness are caused by the pesticides used, as well as the conditions under which each one may cause illness.

Both symptoms and signs serve as clues to pesticide poisoning. Feelings that only the person who has been poisoned can notice--such as nausea or headache--are symptoms. Conditions such as vomiting that also can be noticed by someone else are signs. Know what personal symptoms might mean, and what signs to look for in co-workers and others who may have been exposed.

All pesticides in the same chemical group cause the same kind of sickness. This sickness may be mild or severe, depending on the pesticide and the amount absorbed. But the pattern of illness caused by one type of pesticide is always the same. Having some of the signs and symptoms does not always indicate poisoning since other illnesses may cause similar signs and symptoms; headache and a feeling of being unwell, for example. It is the pattern of symptoms that makes it possible to tell one kind of sickness from another.

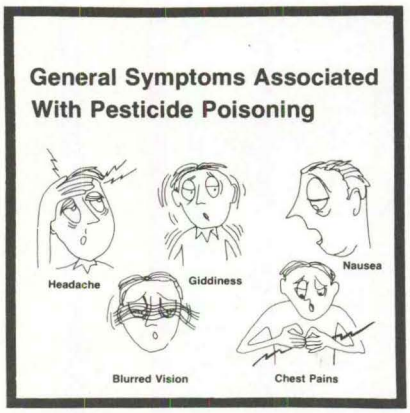
Get medical advise quickly if unusual or unexplained symptoms appear at work or later the same day. A person who may have been poisoned should not be left alone. Do not let anyone get dangerously sick before calling a physician or going to a hospital. It is better to be too cautious than too late. Take the container (or the label) of the pesticide to the physician.

Organophosphates

(Examples are Thimet, Di-Syston, Counter, Dyfonate, Penncap-M, Guthion, Mocap, Cygon.)

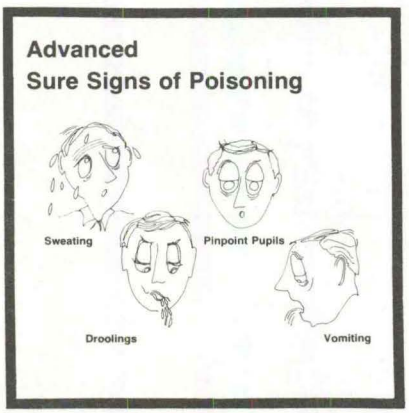
These pesticides injure the nervous system. Organophosphates prevent the action of cholinesterase resulting in excessive activity in the nervous system. The signs and symptoms go through stages. They normally occur in this order:

* Mild Poisoning: fatigue, headache, dizziness, blurred vision, too much sweating and salivation, nausea and vomiting, and stomach cramps or diarrhea.



* Moderate Poisoning: unable to walk, weakness, chest discomfort, muscle twitches, constriction of pupil of the eye, and earlier symptoms become more severe.

* Severe Poisoning: unconsciousness, severe constriction of the pupil of eye, muscle twitches, secretions from mouth and nose, breathing difficulty, and death if not treated.



Illness may be delayed a few hours. But if signs or symptoms start more than 12 hours after exposure to the pesticide, it is probably some other illness. Check with a physician to be sure.

CARBAMATES

(Examples are Temik, Furadan, Lannate, Nudrin, Baygon, Sevin.)

The only carbamates likely to make you ill on the job act almost like organophosphates, producing the same signs and symptoms. The illness caused by carbamates is usually not as severe or as enduring, however, and they are generally considered safer than the highly toxic organophosphates.

PYRETHRINS AND SYMTHETIC PYRETHROIDS

(Examples are Ambush, Pounce, Pydrin.)

Pyrethrin is extracted from the flowers of chrysanthemum plants. Synthetic pyrethroids, which are chemically similar to pyrethrins, are manufactured in pesticide laboratories. Both of these insecticides are highly toxic to insects and fish but less toxic to humans than most insecticides. Pyrethrins and synthetic pyrethroids affect the central nervous system, and extremely high exposure results in convulsions, and lack of coordination. Because of their low level of toxicity, however, pyrethrins and synthetic pyrethroids usually cause only irritation to the skin and eyes.

ARSENICALS

(Examples are Chemonite, Paris Green, Terro Ant Killer, DSMA.)

Ingestion is the route of intake of almost all acute poisoning by the arsenicals. Stomach pain, vomiting and diarrhea are the primary symptoms of acute poisoning. Symptoms are

sometimes delayed for hours. A garlic odor to the breath and feces helps to identify the poisoning agent.

Repeated intakes less then those necessary to produce acute symptoms are chronic headache, stomach pain, and low grade fever.

Cyanide

Cyanide is one of the fastest-acting poisons. Massive doses result in unconsciousness and death without warning. Smaller doses may result in the odor of bitter almonds on the breath, salivation, nausea, anxiety, confusion, dizziness. Illness may last one or more hours, terminating with unconsciousness, convulsions, and death from respiratory failure.

Rodenticides

(Examples are Warfarin Plus, Rodex.)

The injurious effects of anticoagulants are due to loss of blood, mainly into the body tissues. For example, the initial symptoms in chronic warfarin poisoning are back pain and abdominal pain due to buildup of blood in these tissues.

Fumigants

(Examples are methyl bromide, chloropicrin, aluminum phosphide.)

Symptoms of excessive exposure to fumigants are similar to drunkenness (poor coordination, confusion, sleepiness, and unconsciousness). Methyl bromide is extremely dangerous because a toxic or even fatal dose can be absorbed before symptoms appear. Many fumigants can also cause severe chemical burns when trapped against the skin. Do not wear tight clothing or jewelry (even watches or rings) when using liquid fumigants.

Pyridyliums

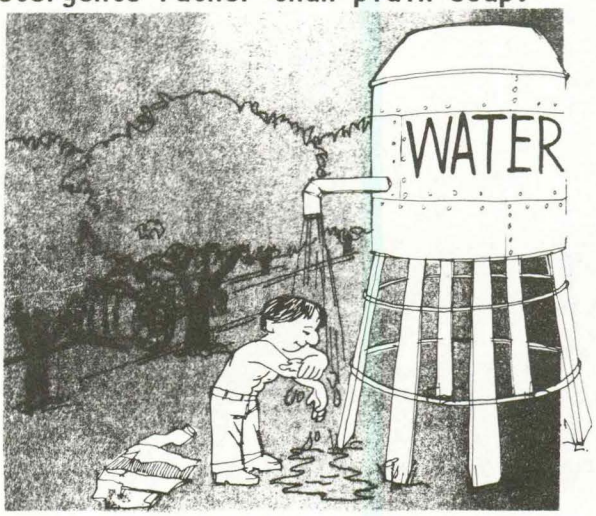
Pyridylium herbicides (paraquat, for example) may be harmful if inhaled or absorbed through the skin, and may be fatal if swallowed. Lung fibrosis can develop if paraquat is swallowed or inhaled. The symptoms of injury may be delayed. Prolonged skin contact will cause severe irritation.

First Aid Procedures for Pesticide Poisoning

Read the directions in the "Statement of Practical Treatment" on each pesticide label. These instructions can save your life and the lives of your employees.

<u>If you get a pesticide on your skin</u>:

Remove the pesticide as quickly as possible. Remove all contaminated clothing. Prompt washing may prevent sickness even when the spill is very large. Do not forget hair and fingernails. Water-wettable powders or suspensions are easy to remove with plain water. So are most emulsifiable concentrates and emulsions. Solutions of pesticides in petroleum oil or other solvents are harder to remove without soap or detergent. Detergents work better. Washrooms and emergency field washing facilities should have detergents rather than plain soap.



If you inhale a pesticide:

Get to fresh air right away.

If you splash a pesticide into your mouth and swallow it:

Rinse your mouth with plenty of water. Go or be taken to a physician immediately. It is sometimes dangerous to cause vomiting; follow label directions.

Preventive Medicine and Pesticide Poisoning

Organophosphate pesticides are involved in more cases of occupational poisoning and death than any other single group of pesticide. Therefore, pesticide applicators using carbamate and organophosphate pesticides on a regular basis should consider having their blood tested to find their normal or base level of a chemical called cholinesterase. This chemical is necessary for the nervous system, and without it, the poison victim will die. Both carbamate and organophosphate pesticides attack this chemical in the blood and make it useless.

Once a pesticide applicator's base level of cholinesterase has been determined by a doctor, a simple blood test will show if there has been overexposure to either an organophosphate or carbamate pesticide. If so, further contact with these pesticides should be avoided until the cholinesterase level has returned to normal. In severe cases, antidotes must be given. Pesticide applicators working with highly toxic carbamate and organophosphate pesticides should have their cholinesterase levels tested at regular intervals throughout the spray season.

Medical Antidotes

By law, highly toxic pesticides must have instructions for the physician on the label in case of a pesticide poisoning. Such instructions will include information on medical antidotes if such information is available. Remember that medical antidotes can be very dangerous if misused. They should never be used as a preventive treatment and should be prescribed and given only by a qualified physician.

In cases where instructions for the physician are not given on the pesticide label, a poison control center or poison treatment center should be contacted.

First Aid Kit for Field and On-the-Job Use

A well-equipped, readily available first aid kit can be important in a pesticide emergency. Make up a kit from a lunch pail, tool box, or a sturdy wooden box. It should have a tight-fitting cover with a latch so that it will not come open or allow pesticides to leak inside. Label it clearly with paint or waterproof marker. A first aid kit for field and on-the-job use should include:

* A small plastic bottle of a common detergent. It is used to quickly wash pesticides off the skin.
* A container of clean water. If there is no clean water in an emergency, use any pond or stream water available.
* Simple bandaids, bandages, and tape. All cuts and scrapes should be covered to prevent pesticide from easily entering the body.
* Several quarters should always be taped to the inside cover of the first aid kit for emergency phones calls.

Iowa Poison Control Centers

Iowa has five Poison Control Centers that anyone can call at any hour for information regarding proper treatment of pesticide poisoning.

Des Moines
515/283-6212
Iowa Methodist Medical Center
(Blank Memorial Hospital)
1200 Pleasant Street
Des Moines 50308

Dubuque
319/589-9099
Mercy Medical Center
Mercy Drive
Dubuque 52001

Fort Dodge
515/573-3101 (x-5757)
Trinity Regional Hospital
Poison Information Center
Kenyon Road
Fort Dodge 50501

Iowa City
800/272-6477
800/272-6103
University of Iowa Hospital
Poison Information Center
Iowa City 52240

Waterloo
319/235-3893
Allen Memorial Hospital
1825 Logan Avenue
Waterloo 50703

Safety Precautions

Recognizing the potential hazards of some pesticides, the responsible applicator will take every precaution to avoid adverse health effects. Keeping your exposure level to a minimum is the key to reducing risk. Reading label directions before each application is important. Make sure you and your helpers follow label directions and the recommendations in this chapter.

Washing

Since pesticides can be absorbed through the skin, it is important to shower at the end of every day when you have been working with pesticides. Wash your hands before eating, drinking, smoking or chewing tobacco, and chewing gum. Take care not to rub your mouth or eyes during application. And since pesticides are absorbed very easily if they contact the genitals, wash your hands before using the bathroom.

In case of spills on the job, have water and soap available where pesticides are mixed and loaded, and in the treatment area as well.

Eating

Never eat or store your food in areas where pesticides are being applied or stored; the food could be contaminated.

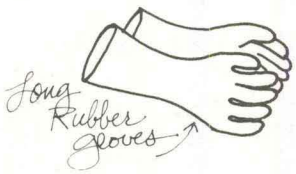
Protective Clothing and Gear

When using any pesticide, regardless of its toxicity, wear at least a hat, long-sleeved shirt, longlegged trousers or a coverall garment, underwear, and socks and shoes. Many times it is advisable to wear coveralls over regular clothing.

When handling pesticide concentrates during mixing and loading, or when using highly or moderately toxic materials, you should also wear rubber boots, rubber gloves, a rubber or vinyl apron, and goggles. An apron will provide protection if the pesticide concentrate is spilled. Trousers should be worn outside of boots, and sleeves outside of gloves to prevent pesticides from getting inside in case of a spill.

If you will be working in a mist, or your clothes will become wet for any reason, wear a waterproof suit. If it is too hot for a heavy rubber rainsuit, wear a lightweight, disposable waterproof suit. The pesticide label indicates whether you should use respirators or take other special precautions for a particular pesticide. Follow the label directions carefully to prevent possible exposure.

Gloves. Generally, when handling concentrated or highly toxic pesticides, wear liquid-proof neoprene or vinyl gloves. They should be long enough to protect the wrist. Gloves should not be lined with a fabric. The lining is hard to clean if a chemical gets on it. Sleeves should be outside of the gloves to keep pesticides from running down the sleeves and into the gloves.



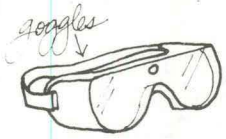
Do not wear cotton or leather gloves. They absorb the pesticide and provide constant exposure, and can be more hazardous then not wearing gloves. Before removing your gloves, rinse them to prevent contaminating your hands.

Gloves can be contaminated on the inside, and the moist warm conditions there may foster pesticide absorption. To avoid this problem, discard gloves often.

Hat. Wear something to protect the head. A wide-brimmed, waterproof hat will protect neck, eyes, mouth, and face. It should not have a cloth or leather sweatband. These sweatbands are hard to clean if chemicals get on them. When spraying in a mist, such as with an air blast sprayer, wear a waterproof parka or hood.

Boots. Generally, wear unlined rubber boots. Leather and canvas shoes absorb and hold pesticides, providing a constant source of skin exposure. Wash boots daily and dry thoroughly inside and outside to remove any pesticide residue.

Goggles or Face Shield. Wear goggles or a face shield when there is any chance of getting pesticides in the eyes. Tight fitting goggles with antifog lenses and indirect venting are best. Wash goggles or face shield with detergent and water at least once a day. Fabric headbands absorb pesticides, and are difficult to clean. Have spare headbands available so that they can be replaced frequently or wear goggles with a rubber strap. Store in a plastic bag away from pesticides to avoid contamination. Wearing contaminated equipment can actually increase rather than prevent absorption.



Wash goggles or face shields at least once a day. Elastic fabric headbands often absorb pesticides and are difficult to clean. Have spares and replace them often, or use neoprene headbands.

Care of Clothing

Wear clean clothing daily. If clothes get wet with spray, change them right away. If they get wet with pesticide concentrates or highly toxic pesticides, destroy them. They are hard to get clean by normal methods.

The following laundering suggestions for care of pesticide-soiled clothing are based on findings from many studies in various parts of the United States as well as on ISU research:

1. Collect pesticide-soiled clothing separately from other dirty laundry. Line a cardboard box with a garbage bag and use this as a disposable hamper; then discard the box when the pesticide application season is finished.

2. Wear rubber gloves to handle pesticide-soiled clothing. Dispose of gloves at the end of the pesticide application season along with the hamper.

3. Wash clothing as soon as possible after each day's soiling to avoid build-up of pesticide residues within the fabric. Although some pesticides deteriorate in air flow over time, this doesn't happen overnight, and you'll want to wear your clothing again before that deterioration has a measurable effect.

4. Wash pesticide soiled clothes separately form family laundry. Pesticides can be transferred from one garment to another in the wash water.

5. Prerinse pesticide-soiled clothes in one of these ways:

   a. Spray or hose them as they hang on a line outdoors. Be sure children and pets are out of the way.

   b. Soak them in a tub or bucket. Throw the dirty water on the field--not on the lawn or garden.

   c. Use the presoak cycle on your automatic washer. Let the presoak water drain, then refill with fresh water for detergent washing.

6. Use hot water (140 degrees F.) setting on your washer. More pesticide is removed when hot water is used, especially with heavyweight fabrics.

7. Avoid over-crowding clothes in the washer. Wash only a few items at one time.

8. Use the full water level. If your washer has a sudsaver feature, don't use it for pesticide-soiled clothing.

9. Use the normal 12 - 14 minute cycle (not a shorter knit cycle) and a double rinse if possible.

10. Use a heavy-duty detergent. Although studies comparing detergent types have been conducted, no significant difference between types has been established with pesticides studied in Iowa for heavyweight fabrics. A 1984 survey showed that most Iowans use powdered phosphate detergents. Laundering research at Iowa State indicates that for Lasso and Dyfonate this is a satisfactory choice.

11. Repeat laundering if evidence of pesticide staining, odor, or other color difference remains in pesticide-soiled clothing after laundering. If repeated laundering does not remove these traces, discard the clothing.

12. Using bleach or ammonia probably will not give added benefit, although this is a commonly held belief. Be careful not to mix these two because they react together to form poisonous chlorine gas.

13. Line dry clothes to avoid possible contamination of your dryer and other family clothes.

14. Rinse washing machine with a load of hot water with detergent, but without clothing, to reduce pesticide residue levels in your washing machine before washing family clothes.

15. Discard any clothing that is fully saturated with full-strength concentrate.

Respiratory Protective Devices

The respiratory tract--the lungs and other parts of the breathing system--is much more absorbent than the skin. Wear an approved respiratory device when the label directs. Follow the label instructions on respiratory protection.

A respirator will be needed if exposed to a pesticide for a long time, if the pesticide used is highly toxic, or if working in an enclosed area.

Chemical Cartridge Respirator. Wear when exposed to intermittent concentrations of a toxic pesticide such as during mixing and loading.

Cartridge respirator

The inhaled air comes through both a filter pad and a cartridge made to absorb pesticide vapors. Most harmful vapors, gases, and particles are removed. These half-face masks cover the mouth and nose. To cover the eyes also, use one that is combined with goggles or wear separate goggles.

Chemical Canister Respirator (Gas Mask). Wear when exposed to a continuous concentration of a toxic pesticide.

The canister has longer lasting absorbing material and filters than a cartridge respirator. Gas masks usually protect the face better than cartridge types, but neither kind protects during fumigation or when the oxygen supply is low, as in a silo.

Canister respirator

Supplied Air Respirator. Wear when the oxygen supply is low, when exposed to high concentrations of highly toxic pesticides in enclosed areas, as in fumigation, or when work can be done close to a supply of clean air. Clean air is pumped through a hose to the face mask.

Supplied air respirator

Self-contained breathing apparatus

Self-contained Breathing Apparatus. Wear this kind of respirator under the same conditions as the supplied air respirator. It operates in similar fashion but cylinders of air or oxygen are carried, usually on the back. Movement is easier and possible over a wider area than with a supplied air respirator.

Selection and Maintenance

Specific types of cartridges and canisters protect against specific chemical gases and vapors. Be sure to choose one made for the pesticide being used. Use only those approved by the National Institute for Occupational Safety and Health (NIOSH), or the Mining Enforcement and Safety Administration (MESA).

The respirator must fit the face well. Long sideburns, a beard, or glasses may prevent a good seal. Before using, read the manufacturer's instructions on the use and care of the respirator and its parts.

During heavy spraying, the filters in chemical cartridge respirators should be changed at least two times a day and more often if breathing becomes difficult. Cartridges should be changed after eight hours use, or sooner if the applicator detects pesticide odor. Filters and cartridges should be removed after each use. The face piece should be washed with soap and water, rinsed, dried with a clean cloth, and stored in a clean, dry place away from pesticides. A tightly closed plastic bag works well for storage.

The useful life of a cartridge or canister depends on the amount of absorbent material, the concentration of contaminants in the air, the breathing rate of the wearer, and the temperature and humidity.

If breathing trouble occurs while wearing a respirator device, see a physician to find out whether a respirator problem exists.

Proper Handling of Pesticides

Many aspects of pesticide application involve some risk of pesticide injury:

* hauling pesticides,
* mixing and loading,
* applying pesticides,
* working in pesticide-treated crops and buildings,
* cleaning application equipment after use,
* cleaning up spills,
* storage, and
* disposing of surplus pesticides and empty containers.

Some of these tasks are done indoors. All require some safety measures to prevent harm to people, animals, and plants as well as to soil and water outside the target area.

To prevent harm from pesticides, follow safety precautions and use common sense. The following paragraphs cover the minimum safety steps to take when handling pesticides. Always start by **Reading the Label.**

Transporting Pesticides

You are responsible for the safe handling of any pesticide from the time that you purchase it until you dispose of the empty container. Transporting concentrated pesticides to and from the storage area carries a high risk of accidental poisoning and environmental contamination.

The safest way to carry pesticides is in the back of a truck. Transporting pesticides in the cab of a truck, car or trunk of a car may expose the driver and any passengers to pesticide fumes or vapors. Fasten down all containers to prevent breakage and spillage.

Keep pesticides away from food, feed, and passengers.

Pesticides should be in a correctly labeled package.

Keep paper and cardboard packages dry.

If any pesticide is spilled in or from the vehicle, clean it up right away. Use correct cleanup procedures.

Do not leave unlocked pesticides unattended. The user is responsible if accidents occur.

Mixing and Loading Pesticides

Some pesticides do not require mixing before they are applied. Baits, garden dusts, granular materials, pesticides contained in pressurized cans and certain liquid household and livestock sprays are ready to use without mixing. Most applicators, however, will purchase concentrated pesticides, such as wettable powders or emulsifiable concentrates, that must be diluted with other liquids (usually water) before they can be used.

The greatest chance of pesticide poisoning occurs during mixing and loading when you are handling the pesticide concentrate. Before handling a pesticide container, put on the correct protective clothing and other necessary protective equipment. Each time that you use a pesticide, carefully read the directions for mixing before removing the material from the container. This precaution is essential because direction, including amounts and methods, are changed periodically.

Follow the precautions outlined below whenever mixing and loading pesticides.

* Always wear rubber or vinyl gloves, a rubber apron, goggles, and a respirator when handling moderately toxic materials, even if the label does not specifically recommend their use.

* Work outdoors. Choose a place with good light and ventilation. If you mix or load pesticide indoors, work where there is good lighting and air circulation.

* When taking a pesticide out of the container, keep the container and pesticide below the eye level. This will avoid a splash or spill on goggles or protective clothing. Do the same thing when pouring or dumping any pesticide.

* Keep livestock, pets, and people out of the mixing and loading area.

* Don't work alone, especially at night.

* Don't tear paper containers to open them. Use a sharp knife. Clean the knife afterwards, and do not use it for other purposes.

* Always stand upwind when mixing or loading pesticides.

* Select an area for mixing and loading that will not contaminate any water supply. If suction hoses are not equipped with good antisiphoning devices such as check valves, the spray mixture from the tank may escape down the hose into the water source. If the applicator allows the tank to run over when filling, the overflow carrying pesticides will usually end up in the water source or as toxic puddles on the ground. Never leave a spray tank unattended while it is being filled.

* If a pesticide is splashed or spilled on you while mixing or loading, stop work and remove contaminated clothing immediately. Wash off thoroughly with soap and water and put on clean clothing.

Avoid Equipment Accidents

Check your equipment thoroughly before you begin. Be sure it is working properly and calibrated correctly. Use the correct nozzles, pressure and droplet size to avoid drift. Be sure that there are no leaks in the pump or tank. Check for leaky hose connections and worn spots in hoses that could burst and splash you or others with pesticide solutions.

If nozzles clog or other problems occur in the field, shut off the sprayer before attempting to correct the problem.

Avoid Exposure

Do not work in drift, spray or runoff unless properly protected. Do not wipe your hands on your clothing if chemicals have been spilled on your gloves. This will contaminate your clothing and may soak through to your skin. Do not blow out clogged hoses, nozzles or lines with your mouth. Even dilute spray mixtures can be toxic. Never eat, drink or smoke when handling pesticides; wash your hands and face thoroughly first. Consider using protective equipment, especially a respirator, even if the label does not call for it.

Watch out for others, too. Supervise your employees and be sure they follow all safety precautions. Always work in pairs when handling hazardous pesticides. Watch carefully for unusual behavior or actions. If you feel sick, do not try to finish the job. Get out of the area fast and get help. Keep children, unauthorized persons and pets out of the area to be sprayed. Do not let children or pets play around sprayers, dusters, filler tanks, storage areas or old pesticide containers. Use the proper rates. Overdoses are misuses. They will not kill pests better than the recommended rate, and may injure humans, crops, or wildlife.

Avoid Sensitive Areas

Avoid spraying near apiaries, lakes, streams, pastures, houses, schools, playgrounds, hospitals or sensitive crops whenever possible. If you must spray, avoid windy days and always spray downwind from the sensitive area. Notify beekeepers and residents when you plan to spray in their areas and urge them to take special precautions. Never spray directly into or across streams, ponds or lakes. Remember that pesticides applied to sandy soils are more likely to leach. Consider spraying structures in the early morning or evening when people and pets are least likely to be exposed. Whenever you spray in residential areas, take every precaution. Be sure toys, pet dishes, aquariums and sensitive plants are removed or covered and children and pets are out of the area.

Avoid Drift

Do not apply chemicals when drift is likely to occur. Select application equipment, formulations, and adjuvants that will minimize drift hazard.

A good applicator carefully checks weather conditions before applying pesticides. A few simple precautions will not only protect the environment but aid the applicator financially. Pesticides that are not deposited on the target areas are wasted. More pesticide, more time, and consequently, more money must be used to control the pests in the target area.

High winds increase drift and result in loss of pesticide on treated areas. Drifting pesticides increase the possibility of injury to wildlife, pollinators, and domestic animals, and may settle on forage, pasture, or wildlife areas, or contaminate water.

Drift into sensitive crop areas can also be avoided by applying pesticides on quiet days. Consider early morning or evening application. Wind speed is usually lowest at these times each day, and drift hazard is greatly reduced. An applicator is legally responsible for any injury or monetary loss of crops because of pesticide drift into nontarget areas.

Safe-Entry Times

It may be dangerous for an unprotected person to enter an area immediately after some pesticides have been used. The time that must pass before the area is safe for a person without protective clothing is called a safe-entry time, or reentry period. This time is given on the label of each pesticide where immediate reentry

may be a problem. It varies according to the pesticide applied and the crop or area treated. These times have been set to allow harmful pesticide residues to break down or disappear. Reentry may pose special problems in some areas. Check with local authorities for any special rules that may apply.

Cleaning Equipment

Mixing, loading, and application equipment must be cleaned as soon as it is finished being used. Clean both the inside and outside including nozzles. Only trained person should do this job. People who clean contaminated equipment should wear protective clothing, including rubber boots, a rubber apron, and goggles.

Have a special area for cleaning. Iowa law requires that the area have a wash rack or concrete apron with a good sump. This will catch all contaminated wash water and pesticides. Keep drainage out of water supplies and streams.

Nozzles should be cleaned with a soft-bristled brush. Do not use a metal object. Never attempt to clean a nozzle by blowing through it with your mouth. Even dilute spray mixtures can be toxic.

Sometimes equipment may need to be cleaned with steam or special cleaning agents. In other cases, hot water and detergent may be enough.

Equipment in which a pesticide has been used should be thoroughly rinsed with a water-detergent solution (2 pounds of detergent in 20 to 40 gallons of water). Allow the water-detergent solution to circulate through the system for several minutes. Remove the sprayer nozzles and screens, and flush the system twice with clean water.

For phenoxy herbicides, such as esters of 2,4-D, rinse with an ammonia or charcoal solution. To make an ammonia rinse, fill the tank one-third to one-half full and add 2 quarts of household ammonia per 25 gallons of water. Circulate the solution, and let a small amount flow through the nozzles. Allow the remaining solution to stand overnight to neutralize any herbicide remaining in the equipment, and then pump the solution through the nozzles. After rinsing with detergent or ammonia, flush thoroughly with clean water.

When storing your sprayer add 1 to 5 gallons of lightweight oil (depending upon the size of the tank) before the final flushing. As water is pumped from the sprayer, the oil will leave a protective coating on the inside of the tank, pump, and plumbing.

To prevent corrosion, remove nozzle tips and screens and store them in a can of light oil such as diesel fuel or kerosene. Close the nozzle openings with masking tape to keep dirt from entering.

Drain the pump thoroughly to prevent freezing. Add a small amount of oil, and rotate the pump four or five revolutions by hand to completely coat interior surfaces. Engine-equipped sprayers require additional servicing. Follow the directions in the owner's manual.

After thoroughly cleaning and draining the sprayer, store it in a reasonably dry and clean building. If you store the sprayer outside, remove the hoses, wipe them clean of oil, and store them inside where they will not become damaged. With trailer sprayers, you may wish to put blocks under the frame or axle to reduce tire pressure during storage.

Pesticide Spills

Even when proper procedures are followed, pesticide spills can occur. Knowing what steps to take in the event of a pesticide spill will allow you to respond quickly and properly.

Remember: Always be sure to wear proper protective clothing when dealing with pesticide spills and to clean up your equipment and clothing when you are finished.

1. **Control the spill.** Immediately after a spill has occurred, make sure that the source of the spill has been identified and controlled, preventing further spillage. As soon as possible call authorities for help and information on controlling the spill.

2. **Contain the spill.** Contain the spill with a dike of soil or sand. It is particularly important not to allow any chemical to get into any body of water, including storm sewers or sanitary sewers. Never hose down spills, as this will only spread the chemical.

3. **Clean up the spill.** Use an absorbent material such as dirt or kitty litter, to soak up the spill. Shovel all contaminated material into a leak-proof container for proper disposal. Once the spill has been cleaned up, it may be necessary to decontaminate the area. Common household bleach is usually an effective chemical for decontamination. However, you should read the label for specific decontamination directions. Additional information will be available by dialing the emergency telephone number listed on the label or by calling Chemtrec (800) 424-9300.

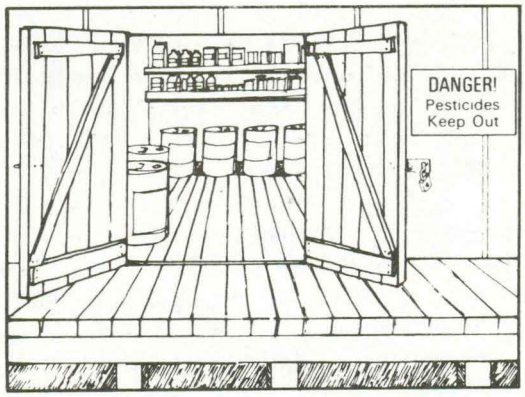
4. **Call the authorities.** All pesticide spills in Iowa must be reported by telephone to the Iowa Department of Natural Resources, 515/281-8694 within 6 hours of occurrence or discovery. The initial report must be followed by a written report to the Department of Natural Resources within 30 days.

Federal law requires immediate notification of the appropriate agency of the U.S. Government of discharge of oil or hazardous substances. Any such person who fails to notify immediately such agency of such discharge shall, upon conviction, be fined not more than $10,000 or imprisoned for not more than one year or both. All major spills should be immediately reported to the Environmental Protection Agency. The telephone number to call in the four-state area of Iowa, Missouri, Kansas and Nebraska is 913/236-3778. The following information should be reported:

* Name, address, and telephone number of persons reporting,
* Exact location of spill,
* Name of company involved and location,
* Specific pesticide spilled,
* Estimated quantity of pesticide spilled,
* Source of spill,
* Cause of spill,
* Name of body of water involved, or nearest body of water to the spill area, and
* Action taken for containment and cleanup.

Storing Pesticides

As soon as pesticides are delivered to your property, you should store them in a locked and posted facility where children and other untrained people cannot get to them. Read the label for correct storage procedures.



Site Selection

When setting up a pesticide storage area, you should check federal, state and local regulations. A number of regulations now require extensive containment facilities at storage sites and the notification of authorities when storing hazardous substances.

You need to keep several points in mind when selecting a pesticide storage area. The site should be in an area where flooding is unlikely. It should be downwind and downhill from sensitive areas such as houses, play areas, and ponds. The site should also be chosen so that runoff or drainage from the site cannot contaminate surface or underground water. Storage facilities should be located away from human and livestock habitations to avoid or minimize contamination in case of fire.

Storage Area

Store pesticides and pesticide containers in a separate building, room, or enclosure, depending upon the size of your pesticide inventory. If your inventory is not large enough to justify a separate building for pesticide storage, completely enclose an area on the first floor of the building. The storage area should keep the pesticides dry, cool, and out of direct sunlight.

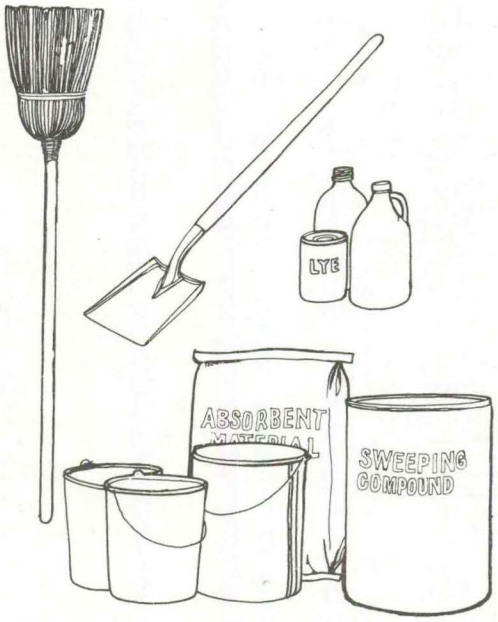
Use an exhaust fan for ventilation in storage rooms to reduce the temperature and high concentrations of toxic fumes. Locate the fan so that exhaust will not damage plants or harm people or animals. Some pesticide requires protection against freezing or extreme heat and have suitable warnings on the label. Sacks, cartons, and fiber boxes should be stored on wooden pallets or on shelves off the floor. The storage area should be securely locked. Weatherproof signs stating Danger--Pesticides. Keep Out! or a similar warning should be hung over every door and window.

Where large quantities of pesticides are stored, fire-resistant buildings, sprinkling systems, and fire-fighting equipment are strongly recommended. Post a list of chemicals and warning signs outside the building, and give a copy to the local fire department.

A drainage system should be built to collect any runoff water. Pesticides that may be present in tank rinsing, spills, seepage from the storage, and heavy runoff from fire-fighting or floods must be controlled. Dikes, collecting pools, and washing slabs with sumps provide a proper drainage system. All the collected runoff water should be treated as a surplus pesticide and disposed of properly.

An adequate supply of detergent or soap, hand cleanser, and water is essential in the storage area. Water is also quick first-aid in a poisoning emergency. Absorptive clay, activated charcoal, vermiculite, pet litter, or sawdust should be readily available at the storage site to soak up spills and leaks. Hydrated lime and sodium

hypochlorite (Clorox or other bleach) should also be on hand to neutralize the pesticide in an emergency. A shovel, broom, dustpan, and a proper type of fire extinguisher are other essential items.



A pesticide storage area, whether it is a cabinet, room, or entire building, should be used only for pesticides and pesticide equipment. Do not store pesticides near food, feed, fertilizers, seed, veterinary medicines, or other stored products.

Glass and metal containers of liquid pesticides should be stored where they are not in the sun or near other sources of heat such as steam pipes. Heat will cause the liquid to expand so that the contents will be under pressure. When the container is opened, the pesticide may splash out on the applicator. No pesticides should be allowed to become overheated. Some formulations will catch fire if they get too hot; others lose their strength and break down when they are exposed to heat.

Store herbicides, insecticides, fungicides, etc. in separate locations within the storage area to prevent contamination and accidental use of the wrong product. In addition, all highly toxic pesticides within a particular group, such as insecticides, herbicides, etc., should be stored together in a special area so that an applicator working in that area can take special precautions to avoid exposure risks.

Store pesticides only in the original container with the label plainly visible. Pesticides should never be stored in anything used as a food or drink container even for a short time. Pesticides stored in a soft drink bottle, fruit jar, milk carton, etc. are a common cause of accidental pesticide poisoning.

All pesticide containers should be checked often for corrosion, leaks, and loose caps or bungs. These dangerous conditions must be corrected immediately. If containers are damaged, you should put the pesticide in a sturdy container that can be sealed. Label the new container immediately. Sometimes you can take the label from the damaged container and fasten it to the new container. Unlabeled pesticides are worthless and dangerous because the applicator does not know what they are or how to use them They should be treated as surplus pesticides held for disposal.

Unlabeled Container Leads to Poisoning

Hospital records indicate that an Iowa farmwife sipped a mouthful of herbicide concentrate from an unlabeled jug. She spat the material out immediately, then washed her mouth out. Later she reported to the hospital emergency room, because of uncertainty about the toxicity of the herbicide. She was hospitalized for four days.

Do not buy more pesticide than you will need. Remove only the amount needed for one day's operation, and be sure to reseal and return any unused pesticide and empty containers to the storage area at the end of each day.

Do not leave empty containers in the fields or on open dumps. Keep all empty containers in a locked storage area until they can be disposed of properly.

Shelf Life of Pesticides

Although pesticides may have a storage life of more than 1 year under optimum conditions, it is advisable not to buy more than will be used in one to two growing seasons. Exposure of liquid, dust, wettable powder and granular formulations to humidity, air, and light, and to temperatures below 40°F or above 90°F may cause deterioration of the chemicals.

Make an inventory of all pesticides in storage and mark containers with the date of purchase. Dispose of pesticides that show the following signs of deterioration:

Formulation	General Signs of Deterioration
Emulsifiable Concentrates	Milky coloration does not occur with the addition of water. Sludge is present or any separation of components is evident in the container.
Oil Sprays	Milky coloration does not occur with the addition of water.
Dusts	Excessive lumping occurs.
Granulars	Excessive lumping occurs.
Aerosols	The aerosol dispenser becomes blocked

Disposal

Excess Pesticides

There are only a few environmentally safe ways to dispose of leftover or unwanted pesticides. Federal guidelines recommend highly sophisticated disposal techniques, such as detoxification, high-temperature incineration, reprocessing of waste, and controlled land disposal. Unfortunately, these recommended disposal techniques are not currently available inside the state of Iowa.

Preventing surplus pesticides is the best way to avoid the disposal problem. However, often times it is not possible to avoid having unusable, damaged, or cancelled pesticides in storage. If possible and legal, use these pesticides by applying them according to label directions.

Pesticides that are in the original container may be returned to the manufacturer. First, check to see if the manufacturing company will take back the surplus pesticides. If it is not possible to properly dispose of the pesticide promptly, store them according to the label directions.

Consult the Iowa Department of Natural Resources for information regarding pesticide disposal. The number to call is 515/281-8690.

Dilute Rinsate Solutions

Waste solutions from washing equipment, rinsing tanks and booms, surplus tank mixtures, and spilled pesticides must be disposed of with minimal impact on the environment. If you mix too much pesticide for a job or get caught with surplus pesticide mixtures, try to find other areas with the same pest problem and use up any extra tank mix or rinse water on these areas.

Pesticide waste materials generated by commercial pesticide applicators

are considered hazardous waste, and must be disposed of in a special or hazardous waste landfill. For this reason, it is advantageous to adopt practices that minimize the amount of waste produced. One technique for reducing the volume of rinse solutions is to carry fresh water on the sprayer to flush the system in the field. When pesticides are applied at less than labeled rates, the rinsate can be applied to the field without fear of crop damage or label violations. If excess pesticide mixtures or rinsate cannot be disposed of immediately, hold the mixtures in temporary storage tanks. Use up the solutions as soon as possible to avoid becoming subject to hazardous waste disposal regulations.

Do not drain surplus pesticides in any location. No pesticide rinsates or wash waters from pesticide equipment should be disposed of through any storm sewer system. Pesticide rinsate or wash waters may be disposed of through sanitary sewer systems with the approvial of the sanitary sewer authority and in accordance with the discharge limitations of a pretreatment agreement or sewer use ordinance.

To avoid being faced with the disposal of a tankful of the wrong pesticide, check out the job carefully before selecting a pesticide. After you have selected the proper pesticide, mix only enough for the particular job so that you end up with an empty tank or hopper.

Containers

Pesticide labels normally provide some information on container disposal. Always comply with the label directions, as well as state and federal regulations. Regardless of the disposal method, all empty pesticide containers (other than paper bags) must be triple rinsed prior to disposal.

Triple rinse all noncombustible containers in the following manner:

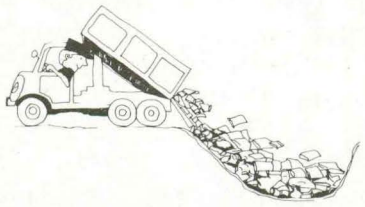
* Empty the container in the spray tank and let it drain for 30 seconds.
* Fill the container one-fifth to one-fourth full of water.
* Replace the closure and rotate the container. Upend the container so the rinse reaches all the side surfaces.
* Drain the rinse water from the container into the spray tank and let it drain 30 seconds after emptying.
* Repeat the procedure at least two more times.

There are some faster alternatives to the rinse, pour and drain routine. An inexpensive jet-spray devise is available that attaches to a hose and is inserted through the bottom of a container to make a vent. A 60-second spray is equivalent to triple rinsing. Another alternative is chemical induction. Several manufacturers produce units that can be installed in place of the commonly used inductor systems. These units, which can be mounted on the sprayer, nurse truck, or on equipment at the plant site, contain rinse units and serve as inductors. They puncture the bottom of the can, drain the pesticide and rinse the can. The rinse material is discharged into the spray tank. Some units also crush the container.

Never reuse a pesticide container once it has been rinsed. Even rinsed containers will still contain some pesticide residues.

Do not casually discard empty containers or allow them to accumulate in an easily accessible area. This will prevent unauthorized salvaging and conversion to other uses. Return rinsed containers to the storage area until it is possible to properly dispose of them.

Move Crushed and Punctured Pesticide Containers to a Sanitary Landfill



Some pesticide containers may be returned to the supplier or to a company specializing in the reconditioning of pesticide containers. All properly rinsed containers may be disposed of by burial in any sanitary landfill that accepts pesticide containers.

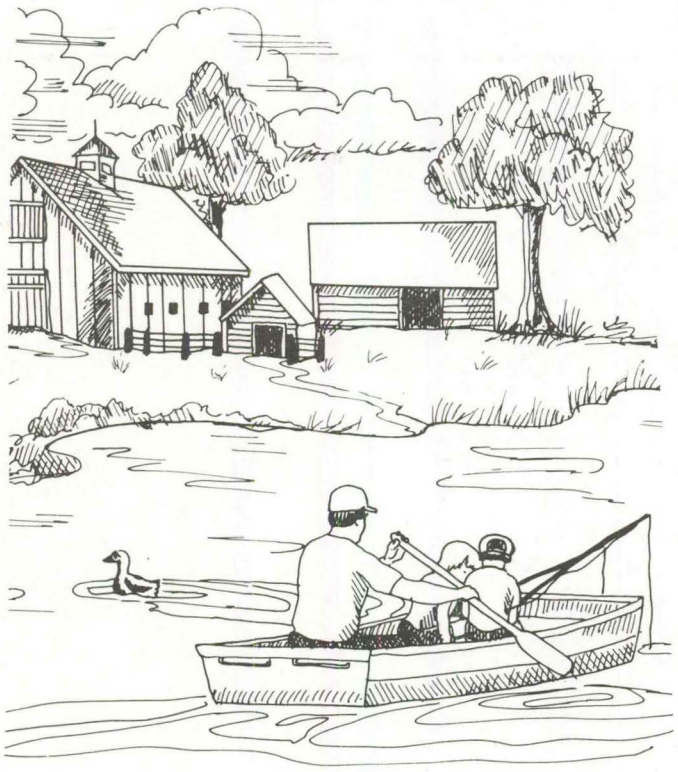
Consult the Iowa Department of Natural Resources for additional information regarding pesticide container disposal.

Illegal Pesticide Disposal Causes Death

An Iowan child found a tablet of Lindane, once manufactured as an insecticide for use in vaporizing devices, and swallowed it. The parents later found the child convulsing and took him to the hospital hours later. The child never regained consciousness and died 87 hours later. The Lindane tablet had been placed in a container and put in a Goodwill donor box, where the child's parents discovered it and brought it home.

Pesticides in the Environment

Although pesticides provide efficient control of pests, they can damage the environment if used improperly. Pesticides cause problems when they move off target--drifting out of the target area; moving by soil runoff or erosion; and leaching through the soil to groundwater. Pesticides can also contaminate the environment, when improper storage and disposal procedures are followed. Careful management of pesticides must be a concern for all pesticide applicators and the public in order to prevent environmental contamination.



Pesticide Drift

Studies have shown that a significant percentage of pesticides never reach the intended site of application, because of drift, volatility, or misapplication. It is impossible to totally eliminate particle drift or volatility, but it is possible to reduce them to acceptable levels. Where significant drift does occur, it can damage sensitive crops, pose health hazards, contaminate soil and water in adjacent areas, and cause considerable friction among neighbors.

Drift can be defined simply as the movement of pesticides through the air to nontarget areas, and may occur either as solid or liquid particles or as vapors.

Spray or Particle Drift. At the time of application, small spray droplets may be carried by air movement from the application site to other areas. The distance a particle of pesticide spray can drift is determined by the following factors: a) the speed of an existing crosswind; b) the distance from the spray nozzle to the ground; and c) the size of the particle itself. Normally, only areas in the immediate vicinity of the application site are affected by particle drift.

Vapor drift. Vapor drift is the movement of a pesticide from the target area as a vapor and results from the tendency of chemicals to volatilize. Where vapor drift occurs, it may affect sensitive areas up to one mile or more from the application site.

Spray Characteristics

The spray characteristics that influence drift are the formulation of the pesticide, the size and density of the drops, and evaporation rate. Dusts drift more than sprays, and granules usually drift least. Some pesticides pose a greater drift hazard than others because small amounts can result in severe environmental damage.

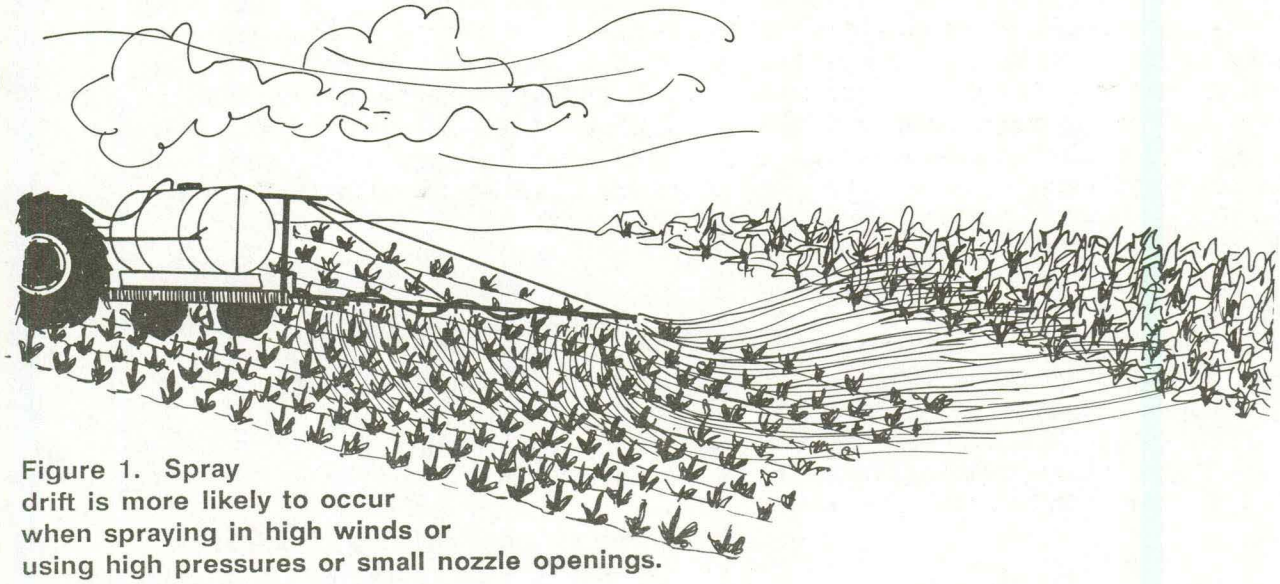


Figure 1. Spray drift is more likely to occur when spraying in high winds or using high pressures or small nozzle openings.

Pesticide Formulation. Very low rates of herbicides such as 2,4-D, dicamba, (Banvel) and picloram (Tordon) can injure sensitive crops such as tomatoes and soybeans. Vapors from some pesticides can drift from treated fields for several days after they are applied. The vapor properties of pesticide products are known, and appropriate formulations can usually be obtained that will not produce unacceptable off-target effects. For example, amine or acid formulations of 2,4-D are less likely to cause damage from vapor drift than ester formulations. The low-volatile ester forms do not vaporize as readily as the high-volatile esters. Vapor drift usually occurs only for three to four days after application; the damage increases rapidly when the temperature rises about 85° F.

Spray Size and Density. Any ingredient in a pesticide formulation that increases the size of spray drops will decrease the amount of particle drift. Increasing the spray viscosity and surface tension reduces the drift potential by producing larger drops. Emulsifying agents and other additives usually increase the spray viscosity, while surfactants decrease the surface tension during application. The density of spray particles determines the distance that they will drift. Since oil drops are lighter than water drops, they tend to stay airborne longer and drift farther.

Evaporation Rate. Evaporation decreases the size of the drops, increasing drift. Water evaporates more rapidly than oils (35 times faster than diesel fuel), and small water drops may evaporate completely before they reach the ground.

Application Equipment and Techniques

Spray drops are measured in microns. One micron is one one-millionth of a meter (25,400 microns equal 1 inch). The drift potential of drops decreases rapidly as the drops increase in size to about 150 or 200 microns in wind speeds of 1 to 8 miles per hour. Water drops under 50 microns will completely evaporate after falling only a short distance from the nozzle. Drops over 150 microns will resist evaporation much more than smaller drops.

Nozzle types and operating conditions greatly influence the size of the drops produced. Conventional nozzles produce a wide range of drop sizes, varying from less than 10

microns to several hundred microns, depending upon the nozzle design and operating pressure. Smaller drops are produced as nozzle pressure increases. To control drift, you should use the lowest pressure that will produce a uniform spray pattern.

Drop size is also related to the nozzle flow rate. Nozzles with large orifices will produce larger drops than nozzles with smaller orifices. You can reduce drift by using larger nozzle tips to apply higher rates of spray solution. Low-pressure and Raindrop nozzles have been designed to reduce the small drops in the spray pattern.

Another technique for controlling spray drift is using thickening agents to increase the viscosity of the liquid. The increased viscosity prevents the formation of many of the small drops that create the drift hazard. Polyvinyl polymer thickeners are now available that are easy to mix, do not require special equipment, and are relatively inexpensive. Thickener concentrations of 2 to 8 ounces per 100 gallons of spray solution drastically reduce the amount of spray drift. You must follow label directions carefully when adding thickeners to the spray tank. Using too much thickener will cause nonuniform spray patterns or can result in nozzle plugging.

Weather Conditions

Wind speed is the major weather condition affecting drift. High winds significantly reduce the number of days when pesticides can be applied safely. In general, air is the least turbulent just before sunrise and just after sunset. Air is usually most gusty and turbulent during midafternoon. Since wind velocities are lower closer to the ground-sprays should be released as close to the target as possible consistent with uniform application.

Temperature and humidity also affect drift. High temperature and low humidity increase the rate of evaporation from spray drops. Small drops that completely evaporate leave crystals of pesticide in the air that are carried through the atmosphere for several days.

The amount of **air turbulence** is determined by the difference between the temperature at ground level and the temperature of the air above it. Normal daytime heating of the soil causes air near the soil surface to be warmer than the air aloft. The warm air rises, setting up air currents. The temperature differential is usually least during early morning or late evening. As the temperature difference increases after sunrise, air currents may carry particles long distances. **Do not apply** pesticides when turbulent conditions exist.

If the air near the soil surface is cooler than the air above it, the warm air overhead remains on top, and no vertical mixing can occur. This condition is known as "inversion." Low wind conditions with high inversion (ground air 2 to 5 degrees F cooler than the air above) may cause the small spray drops to remain suspended in the layer of cold, undisturbed air and eventually move out of the target area. **Do not apply** pesticides when inversion conditions exist.

Pesticide Movement

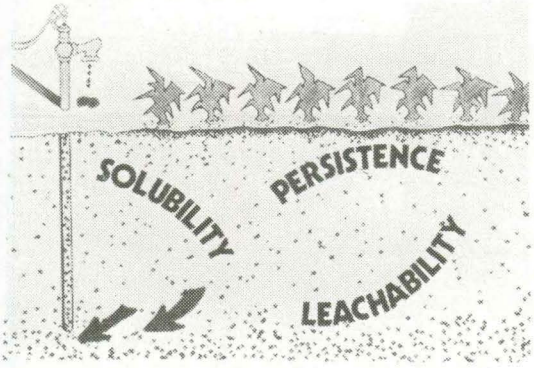
A pesticide can move from the area in which it was applied in a variety of ways. It may volatilize from plant or soil surfaces; it may be moved by wind or water from treated foliage to the soil; it may be carried laterally by surface water runoff or through soil erosion; it may be incorporated into the soil with crop residues; it may be taken from the field as residue on the crop itself; or it may be leached through the soil. Eventually, a portion of the pesticides we apply ends up in the soil. Ultimately,

trace amounts may find their way into surface waters or groundwater.

Many factors determine the extent of pesticide movement that is likely to result from a particular pesticide's use.

Pesticide Properties

Adsorption. Pesticides vary in their degree of attachment or adsorption to soil particles. Some pesticides stick very tightly to soil grains, much like wax sticks to the paint on a car; others stick only loosely, like dust, and are easily dislodged; still others stick a little harder, like caked-on-mud, but can be dislodged with enough water, as in a car wash. Those which are strongly adsorbed are less likely to be carried from the treated area by surface water runoff or leached through the soil into the ground. However, strongly adsorbed particles will be moved by soil erosion.



Water solubility. Pesticides also vary in their ability to dissolve in water or water solubility. Those with greater solubility have a greater potential for movement with water. A heavy rain after a application of a soluble pesticide can move a significant portion away from the target area by runoff or leaching.

Volatility. The volatility of a pesticide is a measure of its tendency to turn into vapor. Pesticides with greater volatility dissipate more rapidly into the air. Once a pesticide has been applied to a soil or plant surface, temperature and humidity will affect the rate of volatilization.

Degradation. The rate of pesticide degradation or chemical breakdown varies with each pesticide. Degradation may be either chemical, physical, or biological or any combination of the three. Temperature, moisture, soil pH, soil type, and fertility affect the rate of biological and chemical decomposition. The rate of degradation slows with decreasing soil moisture and lowering temperatures.

When a pesticide is degraded, it is changed chemically. For most pesticides, once significant degradation has occurred, they are no longer active as pesticides and pose no further risks of pollution.

Persistence. The persistence of a pesticide is a measure of how long it remains in an active form (still controlling pests) in the environment before it is degraded. Persistent pesticides do not react readily with sunlight, oxygen, or heat; are not broken down easily by soil microorganisms; and are only slightly soluble in water.

Persistence may be either desirable or undesirable. Where the objective is long-term control, a persistent pesticide may be desirable. Persistence beyond the time needed, however, is often undesirable and is usually referred to as residue. The pesticide residue may be on the harvested crop or it may be in the soil itself. Any type of residue can cause significant problems. It may make the crop unacceptable for sale or for use as feed or forage. It may also carryover in the soil and adversely affect succeeding crops.

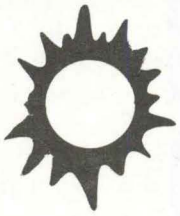
Soil Properties

Many soil characteristics affect pesticide activity and movement, such as soil texture and organic matter.

Texture. Soil texture is determined by the relative proportions of sand, silt, and clay. Texture affects movement of water through soil. The sandier the soil, the faster the movement of percolating water, and the less opportunity for adsorption of dissolved chemicals. Clay soils, on the other hand, are made up of extremely small particles that provide a vast surface area for adsorption. The small pores between clay soil particles slow the movement of water and dissolved pesticides through the soil. The potential for leaching of pesticides into the groundwater is normally greater in sandy soils than clay soils.

Organic Matter. Soil organic matter influences how much water a soil can hold, and how well it will be able to adsorb pesticides. Increasing the soil organic content, increases the soil's ability to hold both water and dissolved pesticides in the root zone where they will be available to plants. While held securely to soil particles, pesticides are kept from washing off the soil surface and from moving down through the soil, and are more likely to be broken down.

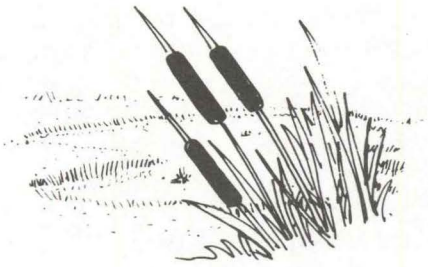
Climatic conditions



The movement and breakdown of pesticides in the soil can be affected by the amount and timing of water applied to the field, either by rainfall or irrigation. If cold rain cools the soil, breakdown reactions can be slowed. It can also wash pesticides off plants and into the soil, removing them from sunlight which might otherwise promote breakdown. Too much water may cause excessive runoff and leaching of pesticides.

Pesticides and Groundwater

Groundwater supplies 70 percent of the water used for public and private water supplies, irrigation and industry in Iowa. Like surface water, groundwater can become polluted. Recent studies have shown that a number of widely used pesticides (atrazine, Bladex, Dual and Lasso) have been found in shallow wells in many locations around the state. Additional monitoring of Iowa's groundwater is underway to help determine the extent of pesticide contamination.



Groundwater is the source of water for wells and springs. It is found underground, within cracks of bedrock or filling the spaces between particles of soil and rocks. The groundwater layer in which all available spaces are filled with water is called the saturated zone. The dividing line between the saturated zone and overlying unsaturated rock or sediments is called the water table. The geologic formation through which groundwater flows is called an aquifer. This can be a layer of sand, gravel, or other soil materials, or a section of bedrock with fractures through which water can flow.

Once groundwater is contaminated, fixing the problem is difficult and may be prohibitively expensive. Another consequence of pesticide contamination of groundwater may be the imposition of restrictions on use of certain pesticides. Clearly, the best solution is to keep pesticides and other contaminants out of groundwater, through careful

application, storage, and disposal practices.

Pesticides can reach groundwater in many ways. Direct contamination can occur as a result of backsiphoning or pesticide spills at the well head. In some areas of the state, sinkholes allow surface water containing pesticides to directly enter the groundwater. Surface streams, contaminated with pesticide may interact with shallow groundwater through subsurface flow. And some pesticides are leached down through the soil.

While it's easy to understand how direct contamination occurs (backsiphoning, spills, surface runoff), it is more difficult to understand how pesticides can leach through soil. For many years it was believed that the soil acted as a filter, preventing the movement of any contaminate into the groundwater. We now know that some pesticides do reach groundwater by moving through the soil. For a pesticide to leach into groundwater and present a hazard, it must move down through the soil and it must resist breakdown to nontoxic compounds. This is generally not a common occurrence and depends on three factors: 1) soil characteristics; 2) pesticides properties; 3) site conditions.

The conditions for each of these factors that will result in pesticide leaching are:

Soil characteristics

* Sandy soil, low in organic matter with large pore spaces and small amounts of surface area will allow leaching through the soil and little attachment of pesticides.

Pesticide properties

* High solubility (the tendency of the pesticide to dissolve in water) increases the possibility that the pesticide will be washed through the soil.
* Low adsorption (weak attraction between the pesticide and the soil particles) of the pesticide to soil particles allows movement through the soil.
* Persistent (the ability to resist breakdown) pesticides are present for longer periods of time, increasing their chance for leaching to the groundwater.

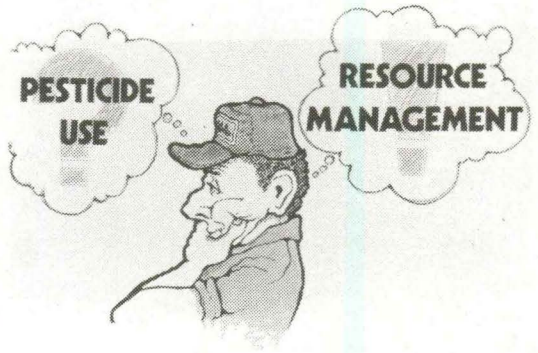
Site Conditions

* A high water table reduces the filtering capacity of the soil and therefore increases the chance of groundwater contamination.
* Heavy rainfall or irrigation may move large amounts of water through the soil, carrying dissolved pesticides.

Reducing Groundwater Contamination Risk

Follow Proper Pesticide Application Procedures

IPM principles should be observed, applying pesticides only when and where necessary and only in amounts adequate to control pests. Other control methods should be utilized whenever possible. Pesticide application equipment should be calibrated regularly to ensure application of the correct rate.



Identify Vulnerable Areas

The presence of sandy soil, sink holes, and shallow groundwater increase the chance of groundwater

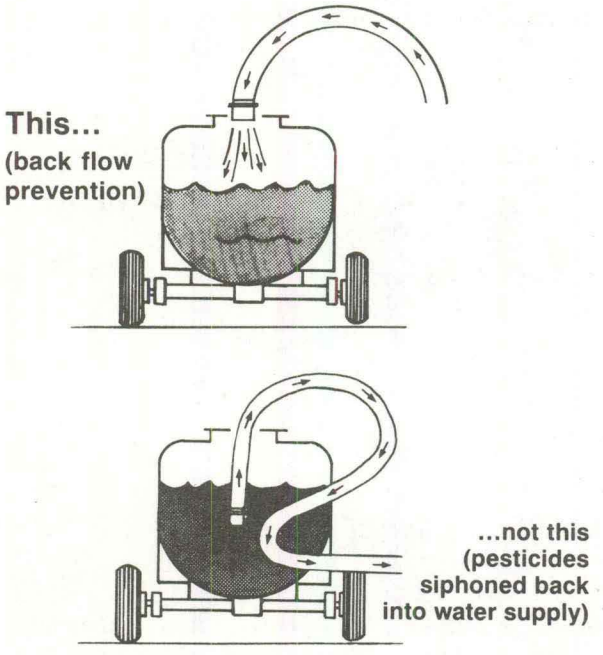
contamination. Avoid pesticide application in those locations. If a pesticide application must be made, apply a pesticide that is less likely to leach, or reduce rates using techniques such as band application of herbicies.

Product Selection

Whenever possible use pesticides that are less likely to leach. Use pesticides that are tightly adsorbed to soil, low in water solubility, not persistent and not highly toxic.

Pesticide Handling

Pesticide spills on the ground or near water sources have the potential for reaching the groundwater. Immediately contain and control pesticide spills. Check application equipment regularly for leaks or damage. Backflow devices should be installed to prevent pesticide contaminated water from backflowing into the water source. Mix and load pesticides only in areas that are diked and away from water sources. After the pesticide application is complete, follow label directions for proper container disposal.



To prevent backflow, put the field hose in top of the tank. Don't let it slide down into the spray solution.

Never dispose of excess spray mix by dumping. If possible apply the material to a labeled site. Be careful not to exceed label rates. Similarly continually rinsing sprayers in the same place can lead to high concentrations of pesticides and groundwater contamination. Rinsing sprayers in the field avoids the problem of containing and properly disposing of sprayer rinsate at a central site.

Pesticide Effects on Nontarget Organisms

The effects of pesticides on nontarget organisms may involve direct and immediate injury or may be due to the long-term consequences of environmental pollution. We will discuss in the following sections the effects of pesticides on nontarget plants, on bees and other beneficial insects, on livestock, and on fish and wildlife.

Effects on Nontarget Plants

Phytotoxicity is simply injury to plants due to exposure to a chemical; phytotoxic injury can occur on any part of a plant -- roots, stems, leaves, flowers, or fruits. Nearly all pesticides can cause plant injury, particularly if they are applied at too high a rate, at the wrong time, or under unfavorable environmental conditions; in some instances, inert ingredients (solvents) can cause plant damage. Most phytotoxic injury is due to herbicides.

Herbicides may damage either the crop plants they are meant to protect, or crops or other plants on adjacent land. Herbicides such as atrazine which are persistent at the site of application may also injure succeeding crops. Damage to crops or other plants in adjacent areas is primarily due to drift, although it may sometimes be a consequence of surface runoff, particularly from sloping areas.

Effects On Bees

Bees pollinate many fruit, vegetable, and field crops. You should be aware of bee activity when applying pesticides. Prevention of bee loss is the joint responsibility of the spray operators, the farmer, and the beekeeper. Before applying pesticides that are toxic to bees, notify commercial beekeepers in the area so that they can protect or move their bee colonies.

Losses of bees to insecticide poisoning can be minimized by being aware of several basic principles:

* Read the label and follow label recommendations.
* Apply chemicals in the evening or during early morning hours before bees forage. Evening applications are generally safer than morning applications. If unusually warm evening temperatures cause bees to forage later than usual, delay the insecticide application.
* Do not spray crops in bloom except when absolutely necessary.
* Do not treat an entire field or area if local spot treatments will control the pest.
* Use insecticides that are relatively nonhazardous to bees, whenever possible.
* Choose the least hazardous pesticide formulations. Emulsifiable concentrates are safer than wettable powders, and granules are the safest and least likely to harm bees.
* Determine if bees are foraging in the target area so protective measures can be taken.
* Airplane applications are more hazardous to bees than ground equipment applications.

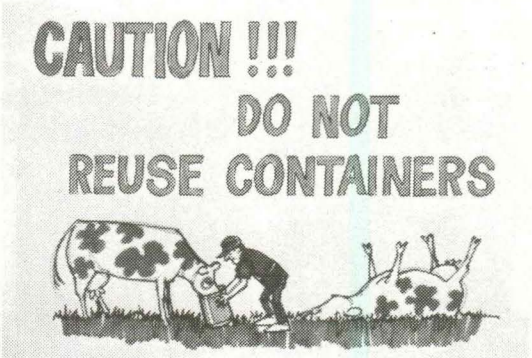
Effects on Other Beneficial Insects

The other major groups of beneficial insects are the predators and parasites of agricultural pests. Despite the fact that they are valuable allies in keeping pest populations below damaging levels, we often overlook them in our pest control efforts. When we apply pesticides, we frequently succeed in reducing their numbers as effectively as those of the pests themselves.

The ideal pesticide is one which selectively control specific pests without harming beneficial species. Unfortunately, few such products have yet been developed. Our best alternative is to select and use pesticides in judicious manner and as part of a integrated pest management program.

Effects on Livestock

The most important source of livestock poisoning by pesticides is contaminated feed or forage and contaminated drinkwater and is often the result of simple carelessness.



There are numerous examples of poisoning that result from improper

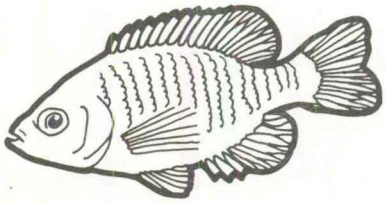
transportation, storage, handling, application, or disposal of pesticides of from a simple lack of attention.

Insecticide Placed in Feed Bag Leads to Death of Dairy Herd

A farmer who had "a little corn rootworm insecticide" left over from planting, placed it in an empty feed mineral bag. He placed the bag near the feed shed, intending to take care of it later. Meanwhile, his hired hand came by to mix some feed for the dairy cattle and noticing the partially full mineral bag, took it with him. The granular pesticide and mineral mix looked similar in appearance, so he poured it in. In the next 24 hours, over 100 dairy cows died.

Effects on Fish and Wildlife

The potentially harmful effects of pesticides on fish and wildlife have been the focus of widespread concern, particularly since the early 1960's.



Damage to fish and wildlife may occur as a direct and immediate consequence of an improper pesticide application (direct fish kill resulting from drift into an aquatic environment), as a result of contamination of wild plants used as a food source, or as a result of indirect pollution from soil erosion, surface runoff and leaching. Except where direct kills are concerned, pesticides with longer persistence are a significantly greater hazard.

Some persistent pesticides are of particular concern because they can accumulate in the bodies of animals in the fat tissue. This process is referred to as **bioaccumulation** or **bioconcentration.** Many of the chlorinated hydrocarbons (DDT, heptachlor, chlordane) are both persistent and accumulative; these combined properties account for most of the environmental problems associated with their use.

Those pesticides which do accumulate in animal tissue may sometimes reach harmful levels in the organism which was initially exposed to the pesticide. More commonly, however, they remain below injurious levels in the initially-exposed organism but become progressively more concentrated in the tissues of animals higher up in the food chain. A **food chain** simply describes the sequence whereby an animal feeds on a particular plant, animal, or microorganism and is in turn eaten by another animal and so forth until we reach the animal at the top of the chain. At each succeeding level, an animal normally eats a number of individuals from a "lower level." An accumulative pesticide can, therefore, become increasingly concentrated as it moves up the food chain; this process is referred to as **biomagnification.** For example, a study has shown that where levels of DDT in the soil were 10 parts per million, it reached a concentration of 141 ppm in earthworms and 444 ppm in robins.

Biomagnification can begin when an animal eats a treated plant or perhaps more frequently when the chemical is absorbed from contaminated soil or water. Biomagnification may be of particular significance in aquatic food chains. Man is normally not affected directly by this process simply because he is usually protected by residue tolerances for the food products he consumes. Fish and wildlife have no such protection and, of course, neither does the fisherman or hunter.

Pest Control and Identification

Pest Control

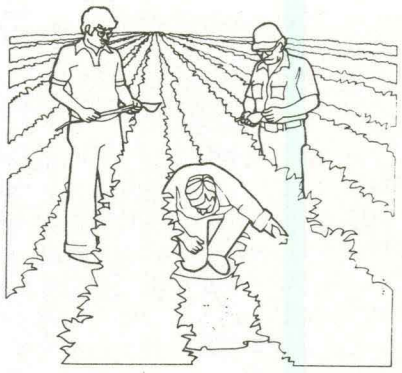
An orderly process of decision making should be followed in order to plan and carry out a pest control program. The principal elements of such a plan are:

* Identify the pest.
* Determine which control methods are available.
* Evaluate the benefits and risks of each method or combination of methods.
* Choose the methods that are most effective and will cause the least harm to the applicator and the environment.
* Know the correct use of the methods.
* Know local, state, and federal regulations that apply to the situation.

Integrated Pest Management

Integrated Pest Management (IPM) is a philosophy of pest control where all available strategies are utilized and optimum yields are realized with the least amount of environmental impact. Integrated Pest Management is a program that emphasizes not only pest control but pest prevention whenever possible. In an Integrated Pest Management program, the grower limits chances of a pest problem by such tactics as timing of tillage, selecting resistant crops, using pesticides judiciously, and other integrated concepts. In IPM, several major strategies work together to manage insects, diseases, nematodes, and weeds while complementing a sound fertility and crop management program. These major strategies are field scouting, economic thresholds, and an integration of chemical, cultural, mechanical, legal and biological control.

Scouting. Field scouting is simply monitoring the crop and pest conditions on a regular basis throughout the year. By scouting the field on a regular basis, the grower can pinpoint problems as they occur and can determine what if any pest control measures are justified, and implement control in a timely fashion.



Economic thresholds. Under an IPM system, management decisions to prevent loss are based on economic thresholds.

The economic injury level is the density of a pest population at which the cost of control equals the amount of crop loss caused by the pest. This level is the maximum number of pests that can be tolerated without significant loss.

The economic threshold is the density of a pest population of which a control measure is justified to prevent an increasing population from reaching the economic injury level.

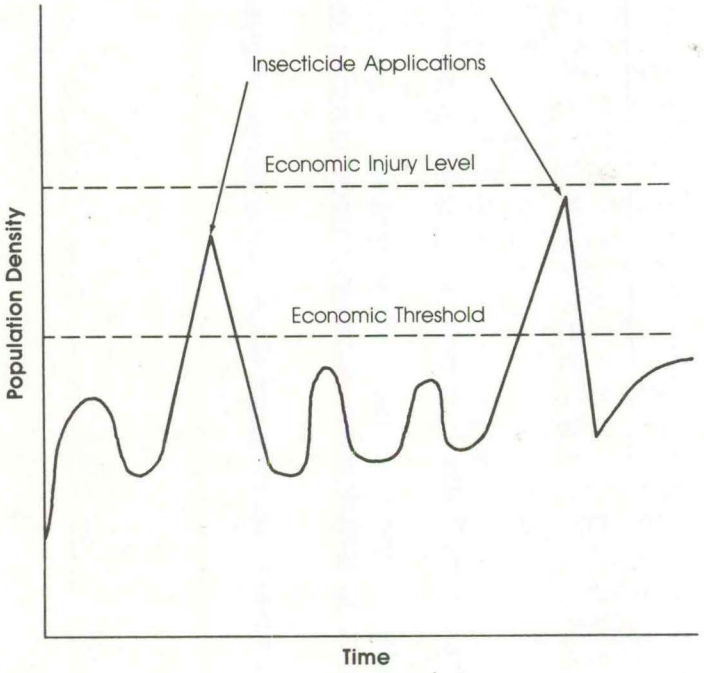


Figure 2. Economic thresholds and injury levels.

Pest populations are "managed" in IPM programs. They are not eradicated, they are not "gotten rid of"--instead they are maintained at levels below the economic threshold. The acceptance of low, noneconomic populations of pests reduces the amount of pesticides used.

Control Methods. Many pest control methods have been known and used for years to reduce pest populations. However, new control methods are being developed. Old methods may be given new or different names or used in different combinations. It is important to stay current on pest control methods.

Our most important pest control methods include cultural, mechanical, legal, biological, and chemical. Of these options, chemical control continues to be the most reliable. However, there have been problems because we have relied on chemicals too heavily in the past. The advantages and disadvantages of pesticide use are outlined below.

Advantages of Pesticide Use:

1. They are effective against thousands of economic pests. No other method of control has this capability.

2. An individual pesticide, or combination of pesticides, can be used to combat several pests on a given crop.

3. They act quickly. Because of this potential for rapid curative action, pesticides are highly effective in controlling populations that are reaching economic proportions.

4. Not only are effective pesticides usually available, but suitable formulations and application equipment also are normally available.

5. Economics continues to favor pesticide use. In return per dollar invested, pesticides still provide the most economical means of controlling many pests.

Disadvantages of Pesticide Use:

1. The broad-spectrum potential of pesticides is not always an advantage because this property creates a potential hazard for the applicator and for other nontarget organisms.

2. Repeatedly exposing a pest population to the selection pressure of pesticides can lead to resistance to individual pesticides or groups of pesticides.

3. Yearly dependence on pesticides is an added cost of production, although pesticides are usually a relatively minor input into total production costs.

4. Whenever a pesticide is used, there is a potential for drift, residues, and damage to beneficial insects such as honeybees and wild pollinators.

It is important to remember, however, that these problems are only potential disadvantages and that a full awareness of potential drawbacks before selecting and using pesticide usually allows us to utilize them in integrated pest management programs.

The implementation of an IPM practice can result in the judicious use of pesticides in a sound management program. Products are employed only with the knowledge there is an economic return, and their use is based on the latest research data. By using pesticides to the best of our knowledge, we limit the amount applied to cropland in Iowa and further reduce the risk of surface and groundwater contamination.

IPM AT IOWA STATE UNIVERSITY

Extension's Integrated Pest Management (IPM) program at Iowa State University is investigating the various factors that affect pest populations. The IPM project began in 1979 with about 2,800 acres of corn, soybeans, and alfalfa being monitored in the Spencer, Des Moines, and Davenport extension areas. By 1983, the project was expanded to more than 20,000 acres located in each of the 12 extension areas. College students who serve as interns are employed each summer to take the field counts of pest populations.

The IPM program also has established a number of services available to growers and agribusiness specialists for pest control. A statewide computer system, based in Ames, handles the data collected by IPM interns in the field throughout the state. The pest information collected in the monitored fields is used to form models for predicting pest populations in various crops, to determine economic thresholds, and to select control alternative.

The information released by the IPM computer system is available to growers daily over live radio (WOI-AM) at 12:15 p.m. and through public television by AGRI-VIEW. Pest information is also available daily to personal computer users via Exnet. Information on accessing this network can be obtained by contacting the IPM office, 103 Bessey Hall, Iowa State University, Ames, Iowa 50011, 515/294-8352.

Several publications related to IPM are available through Publications Distribution, ISU, Ames, Iowa 50011. The *Integrated Pest Management Decision Guide* (IPM-22) has information on scouting, pest identification, and control strategies. *The Crops, Soils and Pest Newsletter* and the *Horticulture and Home Pest Newsletter* are released weekly during the summer and offer information on statewide pests on crops, livestock, ornamentals, turf, and vegetables. Subscriptions for each newsletter ($15.00 per newsletter) are available through Publications Distribution.

Each year IPM also provides a number of scout training meetings across Iowa. Local county extension offices have dates and locations.

One goal of the IPM project is to encourage the development of IPM firms in Iowa. Services vary from scouting

of rootworm beetles to a complete crop management package. Per acre costs range from $2.50 to $7.00 depending on the services. A list of crop consultants is available (IPM-24) from the local county extension office. Several co-ops also are offering service to their customers and provide limited scouting services for growers.

Integrated Pest Management will continue to increase in importance since economical crop production depends on sufficient pest control.

For more information about IPM programs and services contact:

Dean Grundman
103 Bessey Hall
Iowa State University
Ames, Iowa 50011
515/294-8352

Pest Identification and Control

The first step in solving any problem is to understand what is causing it. In this case, the first step is to recognize the pests that must be controlled.

We favor certain plants and animals that provide food and fiber. But in doing so we provide good growing conditions for other plants and animals that harm them and us. These living things that compete with us for food and fiber, or attack us directly, are pests. The living plant or animal a pest depends on for survival is called the host.

Pests can be put into five main groups: insects (plus mites, ticks, and spiders), weeds, plant disease agents, mollusks, and vertebrates.

Most applicators know most of the pests they see on the job. But sometimes unfamiliar pests may appear. Identification aids, publications, and pictures are available, but the best thing to do is to contact local experts. Ask the Cooperative Extension Service or a competent consultant for help.

Insects

Insects thrive in more environments than any other group of animals. They live not only on the earth's surface but within the soil and in water. They are at home in deserts, rain forests, hot springs, snow fields, and dark caves. They eat the choicest foods on our table. They can even eat the table.

This large number of insects can be divided into three categories according to their importance to us:

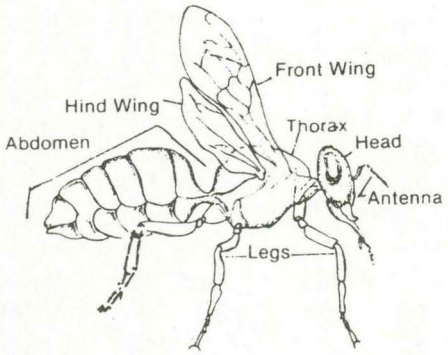
* Species of minor importance include 99 percent of all species. They are food for birds, fish, mammals, reptiles, amphibians, and other insects. Some have aesthetic value.

* 
Beneficial insects are a small but important group that includes predators and parasites, pollinators, and insects that produce silk, dyes and paints.

* Destructive insects are those that usually come to mind when insects are mentioned; this category actually includes the fewest number of species. These are the insects that feed on, cause injury to, or transmit disease to humans, animals, plants, food, fiber, and structures. Destructive insects include aphids, beetles, fleas, mosquitoes, caterpillars, and termites.

Recognizing Common Features of Insects

All adult insects have two things in common--they have six, jointed legs and three body regions. But how do you tell one insect from another? For identification, the most important parts to compare are wings and mouthparts. The wings vary in shape, size, thickness, and structure. Some insects have no wings. Others have two or four.



Insects with chewing mouthparts have toothed jaws that bite and tear the food. Insects with piercing-sucking mouthparts have long beaks that they force into a plant or animal to suck out fluids or blood.

Almost all insects change in shape, form, and size during their lives. This change is called metamorphosis. It may be a gradual change, involving little more than an increase in size or it may be a very dramatic one in which the adult bears little if any resemblance to the young.

In simple metamorphosis the insect that hatches from the egg looks like a miniature copy of the adult. The juvenile forms are called nymphs. These nymphs, which have no wings, go through several growing stages before changing into winged adults. Examples of insects that undergo simple metamorphosis are cockroaches, lice, termites, aphids, and scales.

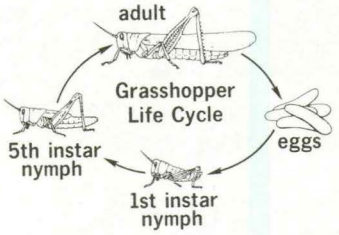


Figure 3. Simple metamorphosis

Other insects undergo complete metamorphosis. They go through four stages. The egg hatches into a larva which may be called a worm, caterpillar, grub, or maggot. This is the stage in which these insects grow the most and do the most damage. When full grown, the larva changes into a pupa. While in the pupa stage the insect develops into its adult form. The adult stage usually has wings. Examples of insects that undergo complete metamorphosis are the beetles, butterflies, flies, mosquitoes, fleas, bees, and ants.

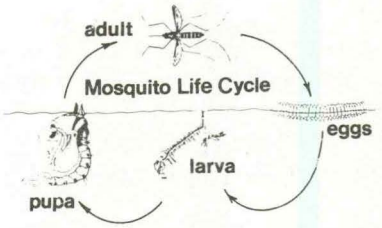


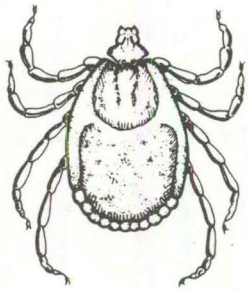
Figure 4. Complete metamorphosis

Insect-like Pests

Mites, ticks, spiders, sowbugs, pillbugs, centipedes, and millipedes resemble insects in size, shape, life cycle, and habits. Pest species usually can be controlled with the same techniques and materials used to control insects.

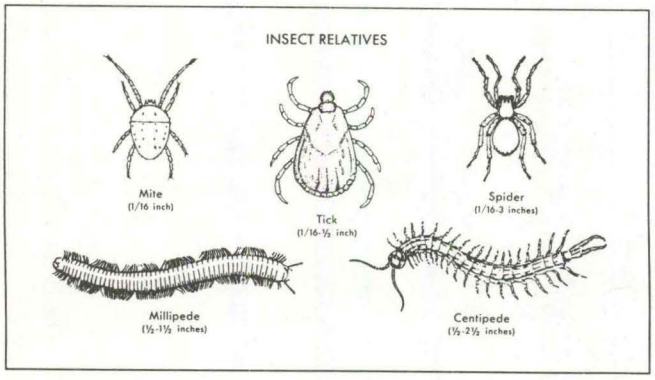
Arachnids Ticks, scorpions, spiders, and mites have eight legs and only two body regions. They are wingless and lack antennae. The

metamorphosis is gradual and includes both larval and nymphal stages. Eggs hatch into larvae (six legs) which become nymphs (eight legs) and then adults. Ticks and mites have modified piercing-sucking mouthparts; spiders and scorpions have chewing mouthparts.



Crustaceans Sowbugs and pillbugs, water fleas, and wood lice have 14 legs. They are wingless and contain only one segmented body region. They have two pairs of antennae and chewing mouthparts. Sowbugs and pillbugs have a hard, protective shell-like covering and are related to the aquatic lobsters, crabs, and crayfish. The metamorphosis is gradual, and there may be up to 20 larval stages before adulthood is reached.

Centipedes and Millipedes Centipedes are made up of 30 segments, each containing one pair of legs. They have chewing mouthparts. Some species can inflict painful bites on humans.



Millipedes contain 30 segments and are cylindrical like an earthworm. The body is wingless and each segment bears two pairs of legs. The antennae are short and mouthparts are comblike. Millipedes feed on decaying organic matter, seeds, bulbs, and roots.

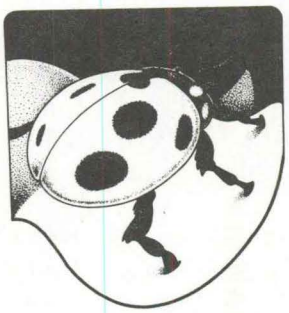
With both centipedes and millipedes there is no metamorphosis; they do not change except in size between hatching and reaching the adult stage.

Controlling Insects and Insect-like Pests

Biological Control

Predators, parasites and pathogenic organisms can have a dramatic effect on insect populations in crops. Unfortunately, they can not always maintain the desired degree of suppression of many pests. Most of our field and vegetable crops are annuals. Annual crops are poor hosts for the survival of predators, parasites and pathogenic organisms because of the continuous interruption of the crop cycle by farming practices. Nevertheless, many insects would regularly emerge as pests if biological organisms were not functioning.

Insect Predators and Parasites. Predators are insects that capture and eat smaller or or more helpless creatures (called prey). Lady beetles and aphid lions (lacewing larvae) are examples of commonly-occurring insect predators.



The term parasite refers to organisms living in or on the bodies of other living organisms (the host); they are usually much smaller than their host and a single individual usually doesn't kill the host.

Several kinds of parasites and predators of the alfalfa weevil have been imported from Europe and Asia and released in this country. Several

species have become established and are helping to reduce pest numbers.

Pathogenic Organisms. Insect pathogenic organisms are naturally-occurring insect pathogens that cause the death of destructive insects. They include viruses, bacteria, fungi, protozoa, and nematodes. These are selective against specific insects or groups of closely-related insects. Man has been able to successfully mass produce some of these agents and use them in a manner which is similar to that of chemical insecticides. Naturally-occurring pathogenic organisms are common and often cause widespread disease epidemics of destructive insects when conditions for pathogen reproduction are ideal. Their high degree of selectivity for specific insects makes them different from the broad-spectrum chemical insecticides which can indiscriminately kill both good and bad insects.

Bacillus thuringiensis (Bt) is an example of a commonly-used bacterial insect pathogen. It will kill only caterpillars and then only specific caterpillars (Lepidoptera). Almost immediately after the Bt is consumed by the caterpillar, a crystalline toxin contained in the dead bacterial cell attacks the insect's gut. The affected caterpillar ceases to feed. Although the insect does not die immediately, the gut eventually ruptures from the action of the toxin and the insect dies.

Sterile Males. Males of some destructive insect species may be reared and sterilized in laboratories and released in large numbers into infested areas to mate with native females. These matings produce infertile eggs or sterile offspring and help reduce the pest population. This technique has been used successfully in only a few species and is still being developed. The screwworm, which attacks cattle, is one insect on which this technique has been effective.

Cultural Control

Some insect pests of field and vegetable crops can be controlled by cultural or management practices. These cultural practices disrupt the insect's life cycle and are usually something the farmer does anyway, such as crop rotation, date of planting, selection of insect resistance varieties, etc.

Crop Rotation. Taking infested fields out of production and leaving them fallow or planting an alternate crop may deprive pests of host plants on which to feed and reproduce.

Delay Planting. Delaying the date of planting may reduce the population of certain pests by eliminating the host plant needed for food and reproduction when the pest population is at its peak. For example, Hessian fly damage in wheat can be avoided by delaying planting until fly reproduction has ended for the year.

Harvest Timing. It is possible to utilize timing of crop harvest to disrupt a developing pest population and eliminate the need for an insecticide. The best example of this in Iowa applies to the alfalfa weevil. If weevils reach damaging levels, immediate harvest can be as effective as insecticides because the exposed larvae often desiccate or starve.

Host Resistance Insect-resistant varieties are based on mechanisms of protection that evolve naturally. Three mechanisms of resistance--nonpreference, antibiosis, and tolerance-- are available; or any combination is possible.

Plants with nonpreference resistance possess characteristics that divert an insect from one variety to another because it may be less suitable for egg-laying, feeding, or shelter. For example, an insect may be repelled by dense hairs on a plant.

Antibiosis involves the presence or absence of plant chemicals that affect insect development and survival by adversely affecting the insect's physiology. An example of this can be seen with first-generation corn borers on field corn. Many varieties contain chemicals which lead to poor survival of the borers when the corn plants are young.

Tolerance resistance refers to a plant's ability to outgrow, repair, or withstand insect damage. Healthy, vigorous plants will be more tolerant of excessive damage. Truly tolerant plants are able to replace, regrow, or repair tissue destroyed by insects. For example, some corn varieties may have a greater capacity to regenerate roots destroyed by corn rootworms.

No method of control is perfect and there are problems associated with developing and utilizing resistant varieties. Development of a resistant variety may take 10-20 years. It may be difficult to incorporate resistance and still maintain high yields in a variety. Finally, insect pests can adapt to resistant varieties. Despite these disadvantages, resistant varieties can be powerful tools in managing insects without the cost and the potential harm to the environment of an insecticide application.

Mechanical and Physical Control

Mechanical and physical controls used on insects include, screens, traps, light, heat and cold, and radiation and electrocution.

Screens and Other Barriers. A major aspect of insect control indoors is the use of screens and other barriers to keep insects out. flying insects, such as mosquitoes, wasps, and flies, are kept outside by blocking any openings with screening. Crawling insects are also kept outside by screens or by other barriers such as tightly sealed doors and windows.

Traps. Traps are sometimes used to control insects. More often, they are used to survey for the presence of insect pests and to determine when the pest population has increased to the point when control is needed.

Chemical control

Chemical insect control includes the use of pheromones, juvenile hormones and pesticides.

Pheromones. Some insects (and insect-like organisms) produce natural chemicals, called pheromones, which cause responses in other insects of the same or very closely related species. Once a particular insect pheromone is identified and the chemical is synthetically produced, it can be used to disrupt the behavior of that insect species. Synthetic pheromones may be used to disrupt normal reproduction, or they may be used to attract the pests into a trap.

Because each pheromone affects only one specific group of insects, their use poses no risk of harm to other organisms, including humans. Unfortunately, only a few have been discovered and produced synthetically, and the use of pheromones is still in the experimental stages. It is very costly to discover, produce, and market a chemical which will be useful in controlling only one pest species.

Juvenile Hormones. Another type of species-specific chemical is also being developed. Juvenile hormones interrupt the metamorphosis of insects (and insect-like organisms). These chemicals prevent reproduction by keeping immature insects from maturing into adults. Each chemical acts against a single pest species and has the same advantages and disadvantages as pheromones. The few juvenile hormones available are usually applied as a broadcast spray to reach as many target pests as possible.

Insecticides. Insecticides act mainly as repellents or direct

poisons. Repellents keep insects away from an area or a specific host. Products designed to keep mosquitoes, chiggers, and ticks off humans are an example of repellents. Direct poisons include insecticides that poison one or more life systems in the pest. Some will poison an insect if they are eaten (stomach poisons); other require only contact with the insect's body (contact poisons).

Weeds

A weed is simply a plant out of place. Weeds are a problem for several reasons. They reduce crop yields, increase costs of production, and reduce quality of crop and livestock products and turf.

Some cause skin irritation and hay fever or are poisonous to humans, livestock, and wildlife. Weeds may harbor insects and disease.

Recognizing Common Features of Weeds

Controlling weeds requires knowledge of how they grow. One important feature is the length of their life cycles.

Annuals

Plants with a one-year life cycle are annuals. They grow from seed, mature, and produce seed for the next generation in one year or less. They may be grasslike (crabgrass and foxtail) or broadleaved (pigweed and cocklebur).

Summer annuals are plants that result from seeds that sprout in the spring. They grow, mature, produce seed, and die before winter. Examples of summer annuals are crabgrass, foxtail, cocklebur, pigweed, and lambsquarters.

Winter annuals are plants that grow from seeds that sprout in the fall. They grow, mature, produce seed, and die before summer. Examples of winter annuals are downy bromegrass, peppergrass, and pennycress.

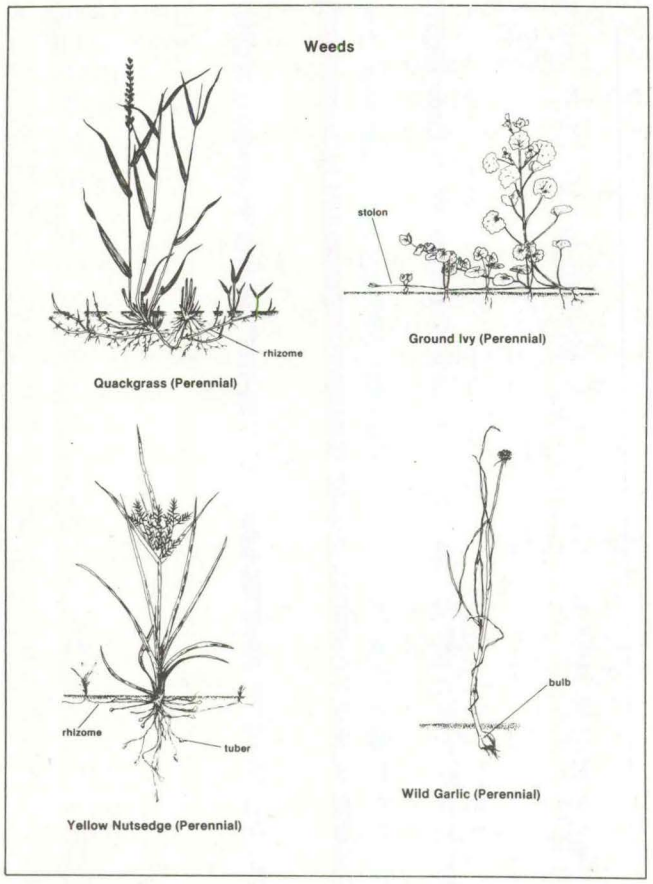
Biennials

Plants with a two-year life cycle are biennials. They grow from seed and develop a heavy root and compact cluster of leaves the first year. In the second year they mature, produce seed, and die. Examples of biennials are mullein, burdock, and bull thistle.

Perennials

Plants that live more than two years and may live indefinitely are perennials. During the winter, many lose their foliage and the stems of others may die back to the ground. Some grow from seed. Others produce tubers, bulbs, rhizomes (below-ground rootlike systems) or stolons (above-ground stems that produce roots). Examples of perennials include quackgrass, field bindweed, dandelion, and plantain.

Creeping perennials produce seeds but also produce rhizomes and stolons. Examples of creeping perennials are quackgrass, milkweed, field bindweed, and Canada thistle.



Simple perennials normally reproduce by seeds. But root pieces may produce new plants following mechanical injury during cultivation. Dandelions, plantain, trees, and shrubs are in this category.

Weeds are often broadly grouped as either **grass** or **broadleaf plants**. Grass plants usually have parallel-veined leaves that are much longer than they are wide. The grasses can be distinguished from one another by differences in their vegetative and reproductive organs. Grasses may be either annuals or perennials; there are no biennial grasses. Annual grasses include crabgrasses, foxtails, barnyardgrass, and fall panicum. Perennial grasses include quackgrass and wirestem muhly.

Broadleaf Plants have net-veined leaves that are usually less elongated than the leaves of the grasses. The arrangement of the leaves along the stem, leaf shape, leaf margins, flowers, and other characteristics (color, root system, etc.) can be used to identify broadleaf weeds. Broadleaf plants are either annuals, biennials, or perennials. Common broadleaves include pigweed, lambsquarters, velvetleaf, jimsonweed, smartweed, morningglory, cocklebur, ragweed, thistle, and bindweed. Woody broadleaf weeds include poison ivy, multiflora rose, wild cherry, and mulberry.

Controlling Weeds

Weed control is nearly always designed to suppress a weed infestation. Prevention and eradication are usually only attempted in regulatory weed programs.

To control weeds which are growing among or close to desirable plants, you must take advantage of the differences between the weeds and the desired species. Be sure that the plants you are trying to protect are not susceptible to the weed control method that you choose. Generally, the more similar the desirable plant and the weed species are to one another, the more difficult weed control becomes. For example, broadleaf weeds are most difficult to control in broadleaved crops, and grass weeds are often difficult to control in grass crops.

Biological Control

Biological weed control usually involves the use of insects and disease-causing agents which attack certain weed species. Attempts are now being made in Iowa to achieve some measure of control of musk thistle through the release of the Musk Thistle Weevil.

Cultural Control

Tillage. This is an effective and often-used method to kill or control weeds in row crops, nurseries, and

forest plantings. However, tillage may bring buried seeds to the surface where they can germinate and compete with the newly planted crop. Tillage also may increase soil erosion and may help to spread established plant diseases to uninfected areas of the field.

Reduced Tillage. This method has been used successfully to reduce weed growth and to reduce soil erosion. With limited tillage, crop residue remaining on the soil surface can act as a mulch, reducing weed seed germination. However, the remaining debris may harbor insects and plant disease agents.

Clean Seed. Weeds often get their starts in fields from a few seeds planted along with crop. Only tested and tagged seed should be planted; certified seed insures high quality seed free of noxious weeds.

Mulching. Mulching is used to prevent light from reaching weed seeds, thus preventing weed growth between rows, around trees and shrubs, or in other areas where no plants are desired.

Mowing. Mowing may be used to reduce competition between weeds and crops and to prevent flowering and seeding of annual or biennial weeds. Mowing is often used in orchards to control weeds and prevent soil erosion. To be most effective, mowing height must be adequate to ensure control of weed plants and encourage desired vegetation. Mowing is an important aspect of turfgrass weed control.

Mowing and harvesting is good for both short-term and long-term control of perennial weeds. It depletes the nutrients, removes seeds, and reduces vegetative spread.

Crop Competition. Crop competition can be a cheap and effective means of at least partial weed control if used to its fullest advantage. It requires selecting the best variety and using the best crop production methods. The objective is to insure that the crop grows so well that, in effect, the weeds are crowded out or, at the very least, the crop becomes a formidable competitor.

Chemical Control

Chemicals used to control weeds are called herbicides. They kill plants by contact or systemic action. **Contact herbicides** kill only the plant parts which the chemical touches. **Systemic herbicides** are absorbed by roots or foliage and carried throughout the plant. Systemic herbicides are particularly effective against perennial weeds because the chemical reaches all parts of the plant--even deep roots and woody stems, which are relatively inaccessible. Contact herbicides are usually used to control annuals and are characterized by the quick die-back they cause. Systemics may take a longer time to provide the desired results--up to 2 or 3 weeks, or even longer for woody perennials.

Herbicide activity is either selective or nonselective. **Selective herbicides** are used to kill certain weeds without significant damage to nearby plants. They are used to reduce weed competition in crops, lawns, and ornamental plantings. **Nonselective herbicides** are chemicals that kill all plants present, if applied at an adequate rate. They are used where no plant growth is wanted, such as fence rows, ditch banks, driveways, roadsides, parking lots, and recreation areas.

Plant growth regulators, defoliants, and desiccatants are classified as pesticides in federal laws. These chemicals are used on plants to alter normal plant processes in some way. They must be measured carefully, because they usually are effective in very small amounts. Overdosing will kill or seriously damage the plants.

A plant growth regulator will speed up, stop, retard, prolong, promote, start, or in some other way influence vegetative or reproductive growth of a plant. These chemicals are sometimes called growth regulators or plant regulators. They are used, for example, to thin apples, control suckers on tobacco, control the height of some floral potted plants, promote dense growth of ornamentals, and stimulate rooting.

A defoliant causes the leaves to drop from plants without killing the plants. A **dessicant** speeds up the drying of plant leaves, stems, or vines. Desiccants and defoliants are often called "harvest-aid" chemicals. They usually are used to make harvesting of a crop easier or to advance the time of harvest. They are often used on cotton, soybeans, tomatoes, and potatoes.

A plant disease is any harmful condition that makes a plant different from a normal plant in its appearance or function.

Three conditions are necessary for a plant disease to occur: 1) a susceptible host plant; 2) a disease-producing agent usually called a pathogen; and 3) a favorable environment for development of the disease. If any one of these conditions is not met, a disease will probably not occur. The interaction of these three conditions is illustrated by the "disease triangle."

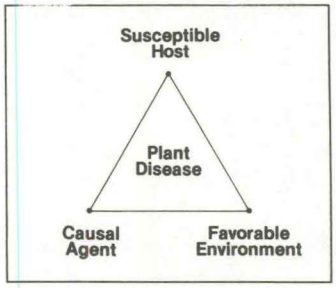


Figure 5. The disease triangle

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

Non-Infectious Plant Diseases

These are caused by nonliving agents and cannot be passed from one plant to another. The causes can include such things as nutrient deficiency, extreme cold or heat, toxic chemicals (air pollutants, some pesticides, salts, too much fertilizer), mechanical injury, and lack of or too much water.

Infectious Plant Diseases

These are caused by microscopic living agents or pathogens that live and feed on or in plants. They can be passed from one plant to another. The most common causes of infectious diseases are fungi, bacteria, viruses, and nematodes. Less common microorganisms such as mycoplasmas, rickettsia-like bacteria, spiroplasms, and viroids can also cause disease. A

few seed-producing plants can cause plant diseases too.

Fungi are microscopic plants that lack chlorophyll (green coloring); therefore, they cannot make their own food. There are more than 100,000 different kinds of fungi. Not all are harmful, and many are helpful. While many fungi are microscopic, the fruiting structures of some are known as mushrooms and may become quite large. Most fungi reproduce by spores, which function about the same way seeds do. Fungi may attack a plant both above and below the soil surface.

Examples of diseases caused by fungi include apple scab, anthracnose of beans, smut in corn, and powdery mildew on landscape plants.

Bacteria are microscopic, one-celled plants. They usually reproduce by simply dividing in half. Each half becomes a fully developed bacterium. Bacteria can build up rapidly under ideal conditions. Some can divide every 30 minutes. Fire blight of pears, halo blight of beans, and bacterial leaf spot on peaches are examples of diseases caused by bacteria.

Viruses are so small that they cannot be seen with the unaided eye or even with an ordinary microscope. They are generally recognized by their effects on plants. Viruses easily overwinter in bulbs, roots, cuttings, and seeds. Many viruses are carried from plant to plant by insects, usually aphids or leafhoppers. Some viruses are transmitted when machines or people touch healthy plants after touching diseased plants. A few are transmitted in pollen, by soil-borne fungi,or by nematodes. Soybean mosaic, tobacco mosaic, and maize dwarf mosaic are examples of diseases caused by viruses.

Nematodes are small, usually microscopic, roundworms, commonly found in the soil. Many nematodes are harmless but others attack a wide variety of crops. Some species attack the above-ground plant parts, such as leaves, stems, and seeds, but most species feed on or in the roots. They may feed at one root location or they may move through the roots. Nematodes usually do not kill plants, but reduce growth and plant vigor. They may weaken the plant and make it susceptible to other disease agents.

All nematodes that are parasites on plants have a hollow feeding spear. They use it to puncture plant cells and feed on the cell contents. Nematodes may develop and feed either inside or outside of a plant. Their life cycle includes an egg, four larval stages, and an adult. Most larvae look like adults, but are smaller. The average life cycle (egg to egg) requires 20 to 60 days. In northern climates, nematodes overwinter mainly in the egg stage.

Development of Plant Diseases

An infectious disease depends on the life of the pathogen. The environment affects this cycle greatly. Temperature and moisture are especially important. They affect the activity of the pathogen, the ease with which a plant becomes diseased, and the way the disease develops.

The disease process starts when the pathogen arrives at a part of a plant where infection can occur. This step is called inoculation. If conditions are favorable for disease development, the pathogen will infect or penetrate the plant. When the pathogen begins to live on host tissue, the tissue is injured or killed resulting in a symptom. At this state, the plant is diseased. Many pathogens may live on a plant without harming it, therefore not causing disease.

A plant responds to pathogens through overdevelopment, underdevelopment, or death of tissue. Overdevelopment of tissue includes such conditions as galls, swellings,

and leaf curls. Underdevelopment of tissue is seen in stunting, lack of chlorophyll, and incomplete development of organs. Death of tissue is evidenced by blights, leaf spots, wilting, or cankers.

Identifying Plant Disease

It is not always possible to tell one plant disease from another just by looking at the plant itself. Because many disease agents cause similar injury, other evidence is needed. Identifying the cause is a better way to identify the disease. A microscope or magnifying lens is usually necessary to see such things as fungus spores, nematodes or their eggs, and bacteria. More training is needed to find and identify the cause of a disease than is needed to observe the effects of the disease on the plant.

Controlling Plant Diseases

In attempting to control a plant disease, it is helpful to remember the three conditions necessary for a disease to occur: a susceptible host plant, a disease-producing agent, and a favorable environment for development of the disease. In selecting a control, consider the cost of the treatment and the life cycle of the pathogen.

Cultural Control

A pathogen and its host must be brought together under specific environmental conditions for a plant disease to develop. Cultural practices are used to alter the environment, the condition of the host, or the behavior of the pathogen to prevent an infection.

Host Resistance The use of disease-resistant varieties is usually one of the most effective, long-lasting, and economical ways to control plant disease, if the resistant varieties are otherwise acceptable. Resistant varieties have long been one of the major factors in maintaining high levels of crop productivity in the United States.

Crop Rotation. Pathogenic organisms nearly always can be carried over from one growing season to the next in the soil or in plant debris. Continual production of the same or closely related crops on the same piece of land leads to a disease buildup. Crop rotation reduces the buildup of pathogens, but seldom provides complete disease control. Obviously, crop rotation is not always possible, practical, or desirable. Perennial crops such as trees, woody ornamentals, and turfgrass must remain in one location for many years. Some crops, such as corn, cotton, or wheat, often are more practical to grow on the same land year after year despite the potential for a buildup of plant disease pathogens.

Proper Planting Time and Methods. Seed rot and seedling diseases are favored by wet and cool soils. Planting should be delayed until the soil moisture and temperature are favorable for seedling development. Optimum soil moisture and temperature will vary with the particular crop species. Improper planting depth can lead to poor stands due to seedling diseases.

Pathogen-Free Seed Stock. Production of clean seed stock is important in reducing plant disease spread. Often, seeds are grown in arid areas where the amount of moisture is controlled by an irrigation system. This eliminates infection by diseases which require high moisture and humidity levels.

Crop Residue Management. Infected crop residues often provide an ideal

environment for carry-over of many pathogens. In some cases the pathogens increase greatly in the residues. Three basic techniques are used in crop residue management:

* deep plowing buries pathogen-infested residues and surface soil and replaces them with soil relatively free from pathogens,

* fallowing reduces pathogen carry-over because their food source decays and is no longer available.

* burning kills some pathogens and removes the residue they live on. This practice may not be legal in some areas.

Disinfecting Equipment and Tools. Some plant diseases can be spread from plant to plant, field to field, and crop to crop by workers and their equipment. Disinfecting equipment, tools, and clothing before moving from an infected area to a disease-free area can prevent or delay disease spread. This method of disease spread is especially important in high humidity and wet field conditions, because the pathogens are transported in the droplets of water which form on the equipment, tools, and skin.

Chemical Control

Chemicals used to control plant disease pathogens include fungicides, bactericides (disinfectants), and nematicides. The general term "fungicide" is often used to describe chemicals which combat fungi and bacteria. Fungicides may be classified as protectants, eradicants, and systemics.

Protectants must be applied before or during infection by the pathogen. In order to be effective, they must either persist or be applied repeatedly. Most chemicals now available to combat plant diseases are protectants.

Eradicants are less common and are applied after infection has occurred. They act on contact by killing the organism or by preventing its further growth and reproduction.

Systemics are used to kill disease organisms on living plants. Systemic chemicals are transported in the sap stream from the application site to other plant parts. This type of chemical may act as both a protectant and an eradicant.

Successful chemical control of plant diseases requires proper timing. Plant disease control on most crops must begin **before** infection occurs. The protectant chemical must be applied when environmental conditions are expected to be ideal for the development of plant pathogens. If the protectant is not applied in time, major crop damage may result or the application of the more expensive eradicant sprays may be needed. Label directions often call for routine protectant applicants every 7 to 10 days during periods of prime infection risk. Almost all plant disease control chemicals are applied as cover sprays. The purpose is to reach and protect all potential sites of infections.

Mollusks--Snails and Slugs

Mollusks are a large group of land and water animals including slugs, oysters, clams, barnacles, and snails. They have soft, unsegmented bodies and often are protected by a hard shell.

Land snails and slugs are soft-bodied and have two pairs of antennaelike structures. Their bodies are smooth and elongated. Snails have a spiral-shaped shell into which they can completely withdraw for protection when disturbed or when weather conditions are unfavorable. Slugs do not have a shell and must seek protection in damp places.

Snails and slugs feed on plants at night. They tear holes in foliage,

fruits, and soft stems, using a rasplike tongue. They may eat entire seedlings. As they move, snails and slugs leave a slimelike mucous trail that dries into silvery steaks. These streaks are undesirable on floral and ornamental crops and on those portions of crops to be sold for human food.

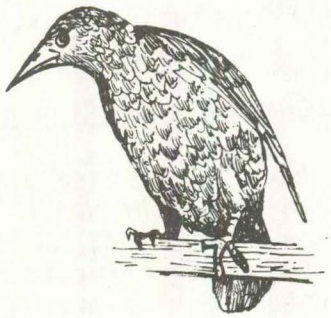
Snails and slugs deposit eggs in moist, dark places. The young mature in a year or more, depending on the species. Adults may live for several years. They overwinter in sheltered areas. They are active all year in warm regions and in greenhouses.

Controlling Mollusks

Occasionally, leaf feeding on vegetable crops will require application of a molluscicide.

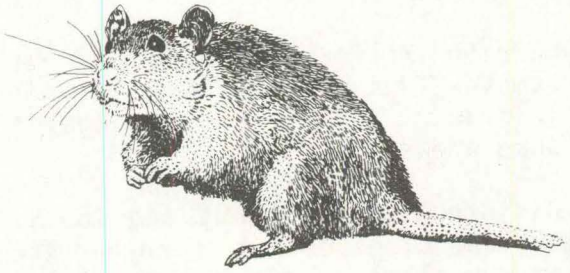
Vertebrate Pests

All vertebrate animals have jointed backbones: mammals, birds, reptiles, amphibians, and fish. Most vertebrate animals are not pests but they are a necessary and enjoyable part of our environment.



A few vertebrate animals can be pests in some situations. Some, such as birds, rodents, raccoons, or deer, may eat or injure agricultural and ornamental crops. Birds and mammals may eat newly planted seed. Birds and rodents consume stored food and often contaminate and ruin even more than they eat. Birds and mammals that prey on livestock and poultry causes costly losses to ranchers each year. Large numbers of roosting birds can soil populated areas.

Rodents, other mammals, and some birds are potential reservoirs of serious diseases of humans and domestic animals such as rabies, plague, and tularemia. Rodents are an annoyance and a health hazard when they inhabit homes, restaurants, offices, and warehouses.



Burrowing and wood chewing mammals may damage dams, drainage and irrigation tunnels, turf, and outdoor wood products such as furniture and building foundations. Beavers may cause flooding in low-lying land by building dams.

Undesirable fish species may crowd out desirable food and sport species. The few poisonous species of snakes and lizards become a problem when humans, livestock, or pets are threatened. Water snakes and turtles may cause disruption or harm in fish hatcheries or waterfowl nesting reserves.

Vertebrate Pest Control

Habitat Manipulation or Sanitation

Removing or modifying one or more of the ingredients (food, water, cover, etc.) necessary to support life.

Exclusion. Keeping animals out of an area through mechanical means. For example, sheet metal and hardware cloth will prevent rats or mice form entering a building or corncrib, and

netting will exclude starlings and sparrows from roosting in or on buildings or from feeding on grapes and cherries.

Repellents. Using chemical or mechanical agents (carbide cannons, etc.) to ward off or frighten pest animals. Chemical repellents may cause animals to experience unpleasant taste, smell, or touch reactions.

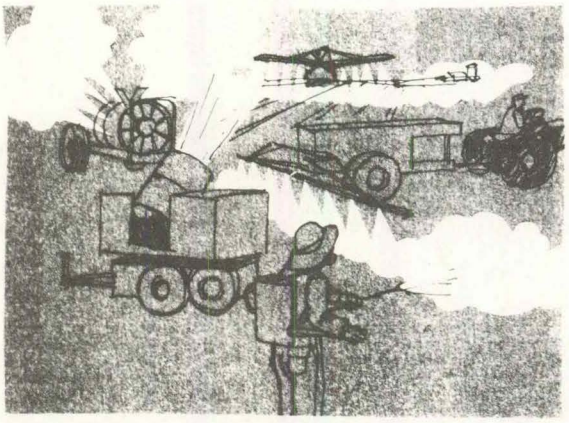
Relocation. Damage by some species can be controlled by trapping and relocating offending animals. This method is especially useful when dealing with protected species (waterfowl, beaver, etc.), or when single animals are causing the damage.

Population Reduction. Killing the animals that are causing damage by shooting, traps, or poisoning. Shooting is effective when single or small numbers of offending animals are present and can be executed legally and safely. Trapping is also effective when it is selective (target species only) or the nontarget species can be released unharmed (live traps). Poisons should only be used as a last resort, and then only in prescribed ways that insure their selectivity.

Application Equipment and Calibration

Application Equipment

The pesticide application equipment used is important to the success of the pest control job. First select the right kind of equipment. Then use it correctly to suit the needs and, finally, take good care of it. This is true whether hand-carried, tractor-drawn, self-propelled, or aircraft-mounted equipment is used.



Small-Capacity Sprayers and Dusters

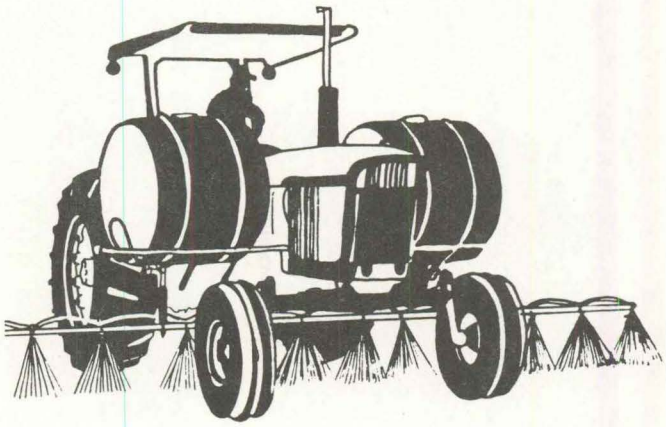
Small-capacity sprayers and dusters are designed for spot treatments, home and garden pest control, small tree and nursery spraying, and for restricted areas unsuitable for larger units.

Most hand sprayers use carbon dioxide or compressed air to pressurize the supply tank, forcing the spray liquid through a nozzle. Several types of small power sprayers are available that deliver 1 to 3 gallons per minute at pressures up to 300 psi. Adjustable hand guns are commonly used with these units, but spray booms are available on some models. These sprayers are relatively inexpensive, simple to operate, highly maneuverable, and easy to clean and store.

Like hand sprayers, hand dusters are used primarily for small areas. They may consist of simply a squeeze tube or shaker, a sliding tube, or a fan powered by a hand crank. One advantage of hand dusters over sprayers is that the pesticide has been prediluted, and is ready to apply on small areas for spot treatment.

Low-Pressure Sprayers

Low-pressure sprayers are used to apply chemicals to control weeds, insects, and diseases in field crops, ornamentals, turf, fruits, vegetables, rights-of-way, etc. Tractor-mounted, pull-type, and self-propelled sprayers are available in many models. Small tank sprayers (50 to 200 gallons) requiring low flow rates usually have roller pumps with outputs ranging from 5 to 30 gallons per minute and maximum spraying pressures ranging from 150 to 200 psi.

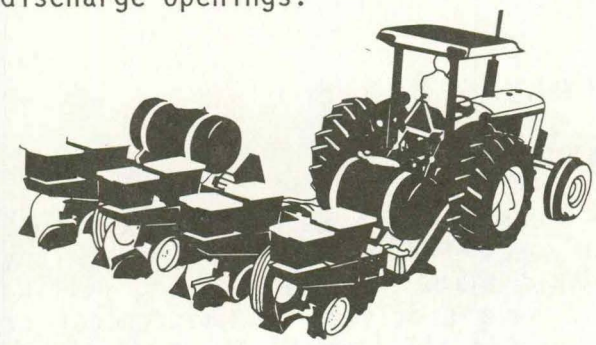


All low-pressure sprayers are composed of several basic components: a pump, a tank, an agitation system, a flow control assembly, and a distribution system.

Granular Applicators

Granular applicators are relatively inexpensive and simple to use, but they must be calibrated carefully. Available units range from hand-operated applicators for lawns, to band applicators for row crops, to powered applicators covering wide swaths. Granular applicators distribute granules in several ways, including pneumatic (air carriers), whirling discs (seeders, fertilizer spreaders), multiple-hole gravity or force-feed spreaders (lawn spreaders, broadcast drills), soil injectors (furrow treatments), and ram air (aircraft).

The granules are usually metered by gravity flow or positive feed. Gravity-flow applicators are the most common, and consist of a hopper with a metering orifice in the bottom. Granules flow through the orifice by gravity. An agitator rotating in the bottom of the hopper above the orifice prevents the granules from bridging and blocking the orifice. Positive metering applicators have an auger or a notched rotor that rotate in the bottom of the hopper to deliver a constant amount of granules to the discharge openings.



High-Pressure Sprayers

High-pressure sprayers are used primarily for spraying fruits, vegetables, and trees for disease and insect control. These sprayers provide the high pressure necessary to produce small drops for complete coverage of the fruit and foliage. They are also used for spraying ornamentals and livestock and to wash equipment.

High-pressure sprayers are similar in design to low-pressure, general-use sprayers except that they have piston pumps. The pumps deliver up to 50 gallons per minute at pressures as high as 1,000 psi. All components are designed to withstand the high pressures. Field booms are available for specific crop uses, such as tomato, grape, or orchard spraying. Hand guns can be used for spraying large trees or livestock. When fitted with the proper pressure regulators, high-pressure sprayers can serve as general-use sprayers at low pressures.

Air Blast Sprayers

Air blast sprayers use a combination of air and liquid rather than liquid alone to deliver the pesticide to the surface being treated. They are used in agricultural, ornamental and turf, biting fly, forestry, livestock and right-of-way pest control operations.

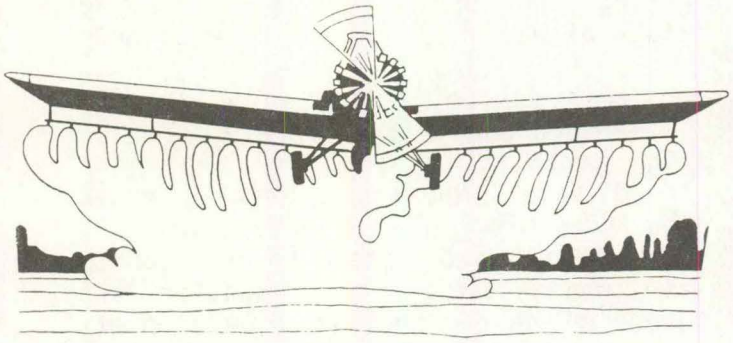
These sprayers usually include the same components as low-pressure or high pressure sprayers, plus a high-speed fan. Nozzles operating under low pressure deliver spray droplets directly into the high-velocity airstream. The air blast shatters the drops of pesticide into fine droplets and transports them to the target. The air blast is directed to one or both sides as the sprayer moves forward, or it may be delivered through a moveable nozzle.

Most air blast sprayers are trailer-mounted, but tractor-mounted models are available. Tank capacity ranges from 100 to 1,000 gallons. Most of these sprayers can be adapted to apply either high or low volumes of spray material as well as concentrates. Mechanical agitation of the spray mixture is usual. An air blast sprayer may cover a swath up to 90 feet wide and reach trees up to 70 feet tall.

Aerial Sprayers and Granular Applicators

Aerial sprayers and granular applicators are designed for both fixed-wing airplanes and helicopters. Because of the limited carrying capacity of aircraft, spray materials are usually applied in concentrated form. Spray is commonly applied 3 to 25 feet above the tops of the plants, at a rate of 1 to 10 gallons per acre, and at speeds ranging from 80 to 125 miles per hour. Most aircraft are designed to apply both liquid and granular materials.

Fixed-wing airplanes can travel long distances but require landing strips for frequent reloading. Helicopters are more maneuverable in rough terrain than fixed-wing aircraft, and are not restricted to operating from a landing strip; however, they are more expensive and have a smaller payload.



Ultra Low Volume (ULV) Sprayers

These sprayers use a special type of nozzle which spins at a high speed and breaks the liquid into uniformly sized droplets by centrifugal force. The droplets may be carried to the target by gravity or by an airstream created by a fan. Power to spin the nozzles is provided by small electric or hydraulic motors. Sizes range from a small hand-held type to large tractor-mounted and trailer-mounted units.

Recirculating Sprayers

These devices usually are used to apply translocated herbicides to weeds which are taller than the crop in which they are growing. Solid streams of highly concentrated herbicides are directed across rows above the crop. Spray material which is not intercepted by the weeds is caught in a box or sump on the opposite side of the row and is recirculated.

Wiper Applicators

These devices are used to apply translocated herbicides selectively to weeds in crop areas. Wicks made of rope, rollers made of carpet or other material, or absorbent pads made of sponges or fabric are kept wet with a concentrated mixture of herbicide and water and brought into direct contact with weeds. The herbicide is "wiped" onto the weeds, but does not come in contact with the crop. Application may be to tall weeds growing above the crop or to lower weeds between rows, depending on the way the wiper elements are designed. Pumps, control devices, and nozzles are minimal or are eliminated altogether, and tanks are quite small because of the small amount of liquid applied.

Sprayer Parts

Tanks

Tanks should have large openings for easy filling and cleaning. They should allow straining during filling and have provision for mechanical or hydraulic agitation. The tank should be made of corrosion-resistant material such as stainless steel or fiberglass. If made of mild steel, it should have a protective lining or coating.

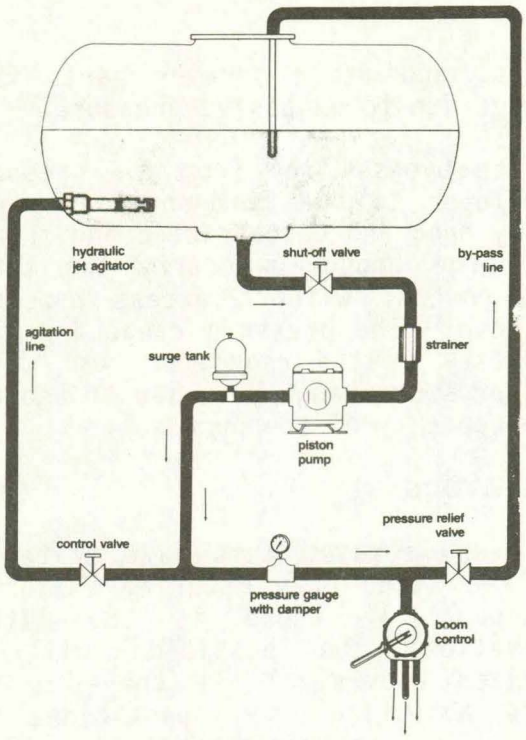


Figure 6. Spraying system with a piston pump

The tank should have a large drain, and other outlets should be sized to the pump capacity. If you use dual tanks, make sure the plumbing allows for agitation and adequate withdrawal rates in both tanks. All tanks should have a gauge to show the liquid level. External gauges should be protected to prevent breakage. All tanks should have a shut-off valve for storing liquid pesticide temporarily while other sprayer parts are being serviced.

Pumps

The pump must have sufficient pumping capacity to supply the needed volume to the nozzles and to the hydraulic agitator (if necessary) and to maintain the desired pressure. The pump parts should be resistant to corrosion and abrasion if abrasive materials such as wettable powders are to be used.

Never operate a sprayer pump at speeds or pressures above those recommended by the manufacturer. Pumps will be damaged if run dry or with restricted inlet or outlet. Pumps depend on the spray liquid for lubrication and removal of the heat of friction.

Strainers (Filters)

Pesticide mixtures should be filtered to remove dirt, rust flakes, and other foreign materials from the tank mixture. Proper filtering protects the working parts of the sprayer from undue wear and avoids time loss and uneven application caused by clogged nozzle tips.

Filtering should be progressive, with the largest mesh screens in the filler opening and in the suction line between the tank and the pump. They should be keyed to the size of the nozzle opening. Total screen area should be large enough to prevent pump starvation. Put the finest mesh strainer nearest the nozzles. Do not use a strainer in the suction line of a centrifugal pump, but be sure the tank has a strainer to take out large particles.

Strainers should be placed:

* on the filler opening (12 to 25 mesh),
* on the suction or supply line to the pump (15 to 40 mesh),
* between the pressure relief valve and the boom (25 50 100 mesh),
* on the nozzle body (50 to 100 mesh).

Clean strainers after each use, or during use if they become clogged. A shut-off valve between the tank and suction strainer is necessary to allow cleaning the strainer without draining the contents of the tank. Replace damaged or deteriorated strainers.

Nozzle strainers or screens should be as large as nozzle size permits; however, the screen opening should be less than the nozzle opening. Nozzle catalogs specify the proper screen size for each nozzle.

Hoses

Select neoprene, rubber, or plastic hoses that:

* have burst strength greater than the peak operating pressures,
* have a working pressure at least equal to the maximum operating pressure,
* resist oil and solvent present in pesticides,
* are weather resistant.

Suction hoses should be reinforced to resist collapse. They should be larger than pressure hoses, with an inside diameter equal to or larger than the inlet part of the pump. All fittings on suction lines should be as large as or larger than the inlet part of the pump.

Keep hoses from kinking or being rubbed and rinse them often, inside and outside, to prolong life. During the off season, store the unit out of the sun. Replace hoses at the first sign of surface deterioration (cracking or checking).

Pressure Gauges

Pressure gauges monitor the function of your spraying system. They must be accurate and have the range needed for your work. For example, a 0 to 100 psi gauge with a 2-pound gradations would be adequate for most low-pressure sprayers.

Check frequently for accuracy against an accurate gauge. Excess pressure will destroy a gauge. If yours does not zero, replace it. Use gauge protectors to guard against corrosive pesticides and pressure surges.

Pressure Regulators

The pressure regulator controls the pressure and, indirectly, the quantity of spray material delivered by the nozzles. It protects pump seals, hoses, and other sprayer parts from damage due to excessive pressure.

The bypass line from the pressure regulator to the tank should be kept fully open and unrestricted and should be large enough to carry the total pump output without excess pressure buildup. The pressure range and flow capacity of the regulator must match the pressure range you plan to use and the capacity of the pump.

Agitators

Every sprayer must have agitation to keep the spray material uniformly mixed. If there is too little agitation, the pesticide will be applied unevenly. If there is too much agitation, some pesticides may foam and interfere with pump and nozzle operation. The type of agitation necessary depends on the pesticide formulation to be used.

Bypass Agitators

Soluble powders and liquid formulations such as solutions and emulsifiable concentrates require little agitation. Bypass agitation is sufficient for these formulations. Bypass agitation uses the returning liquid from the pressure relief valve to agitate the tank. The return must extend to the bottom of the tank to prevent excessive foaming.

Bypass agitation is not sufficient for wettable powders, dry flowable and flowable formulations or in tanks larger than 55 gallons unless a centrifugal pump is used. Centrifugal pumps usually have large enough outputs to make bypass agitation adequate even for wettable powders in tanks less than 100 gallons.

Hydraulic (Jet Action) Agitators

Hydraulic agitation is required for wettable powder and flowable formulations in small tanks and for liquid formulations in 100-gallon or

larger tanks with gear, roller, piston, or diaphragm pumps. Hydraulic agitation is provided by the high-pressure flow of surplus spray material from the pump. The jet or jets are located at the bottom of the tank. The agitator is connected to the pressure side of the pump. Jet agitator nozzles should never be placed in the bypass line. The pump and tank capacity and operating pressure determine the minimum jet number and size:

* 55 gallon = 1 or more jets,
* 100 to 150 gallon = 3 or more jets,
* 200 gallon and larger = 5 or more jets

Mechanical Agitation

Wettable powder formulations are best mixed and kept in suspension with mechanical agitation. The mechanical agitator usually consists of flat blades or propellers mounted on a shaft which is placed lengthwise along the bottom of the tank. The paddles or propellers are rotated by the engine to keep the material well mixed. Mechanical agitators are usually found only on large high-pressure hydraulic sprayers.

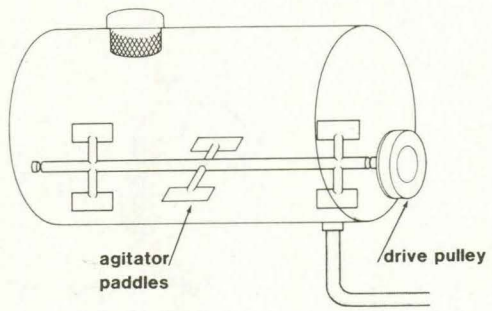


Figure 7. Mechanical agitation

Control Valves

A quick-acting cutoff valve should be located between the pressure regulator and the nozzles to provide positive on-off action. These control valves should be rated for the pressures you intend to use and should be large enough not to restrict flow when open. Cutoff valves to stop all flow or flow to any section of the spraying system should be within easy reach of the sprayer operator.

There are many kinds of control valves. Mechanical valves must be accessible to the operator's hand; electrically operated valves permit remote control of flow. For tractors or self-propelled sprayers with enclosed cabs, the remote-controlled valve permit all hoses carrying pesticide to be kept safely outside the cab.

Nozzles

Regardless of the type of sprayer used, the proper selection of nozzle type and size is the most important part of pesticide application. It is impossible to over-stress the importance of proper nozzle selection and use. The nozzle determines the amount of spray applied to a particular area, the uniformity of the applied spray, the coverage obtained on the sprayed surfaces, and the amount of drift. You can minimize drift by selecting nozzles that give the largest drop size, while providing adequate coverage at the application rate that you have selected.

Nozzles are made up of four major parts: the nozzle body, the cap, the strainer (screen), and the tip or orifice plate. They may also include a separate spinner plate. Successful spraying depends on the correct selection, assembly, and maintenance of the nozzles.

The nozzle **body** holds the strainer and tip in proper position. Several types of tips that produce a variety of spray patters may be interchanged on a single nozzle body made by the same manufacturer.

The **cap** is used to secure the

strainer and the tip to the body. The cap should not be over tightened.

The **nozzle strainer** is placed in the nozzle body to screen out debris which may clog the nozzle opening. The type of nozzle strainer needed depends on the size of the nozzle opening and the type of chemical being sprayed.

Special nozzle screens fitted with a check valve help prevent nozzle dripping. Check valves should be used in situations where a sprayer must be stopped and started frequently, such as in small target areas, near sensitive crops or areas, indoors, or for right-of-way treatments. The operator must check these spring-loaded ball valves frequently to assure proper operation.

Nozzle tips break the liquid pesticide into droplets. They also distribute the spray in a predetermined pattern and are the principal element that controls the rate of application. Nozzle performance depends on:

* nozzle design or type,
* operating pressure,
* size of the opening,
* discharge angle,
* distance of nozzle from the target.

Nozzle Patterns

Nozzle patterns are of three basic types: solid stream, fan, and cone. Some special-purpose nozzle tips or devices produce special patterns. These include "raindrops," "flooding" and others that produce wide angle fan or cone-shaped patterns.

Solid Stream Nozzles

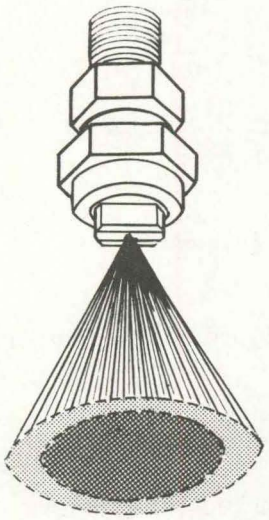
These nozzles are used in handgun sprayers to spray a distant or specific target such as livestock, nursery, or tree pests, and for crack and crevice treatment in and around buildings. They also may be attached to booms to apply pesticides in a narrow band or inject them into the soil.

Fan Pattern Nozzles

At least three types of nozzle tips have fan patterns. They are used mostly for uniform spray coverage of surfaces: for example, applying herbicides or fertilizers to soil.

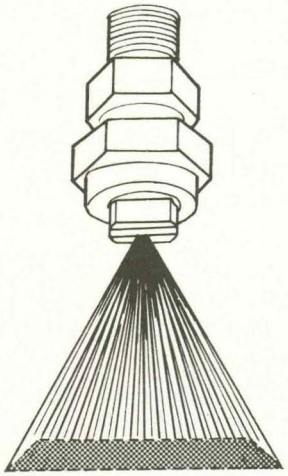
The **regular flat fan** nozzle tip makes a narrow oval pattern with tapered ends. It is used for spraying at 15 to 60 psi. When applying herbicides with flat-fan nozzles, keep the operating pressure between 15 and 30 psi. At these pressures, flat-fan nozzles produce medium-to-coarse drops that are not as susceptible to drift as the finer drops produced at pressures of 40 psi or higher. Some foliar herbicides are recommended for application at 40 to 60 psi to obtain maximum coverage on the plant surface.

The pattern is designed to be used on a boom and to be overlapped 30 to 50 percent for even distribution. Regular flat-fan nozzles are available in several selected spray-fan angles, although 80-degree spray-angle tips are most commonly used. The nozzles are usually on 20 inch centers at a boom height of 10 to 23 inches.



Regular flat fan nozzle

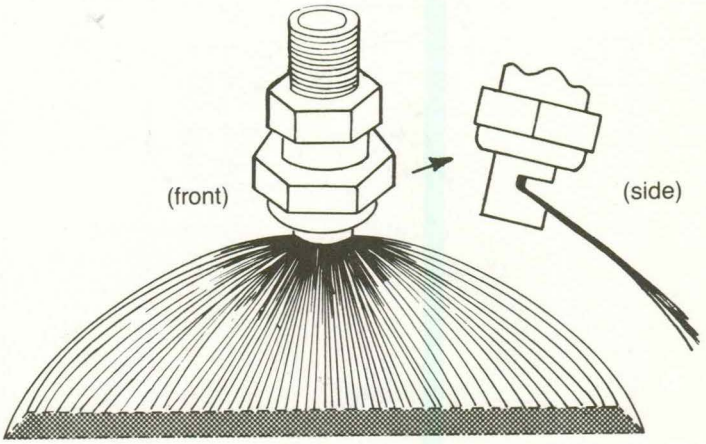
The **even flat fan** nozzle makes a narrow oval pattern. Spray delivery is uniform across its width. It is used for band spraying and for treating walls and other surfaces. It is not used for broadcast applications. Even flat-fan nozzles should be operated between 15 and 30 psi. Boom height and nozzle spray angle determine the width of the band sprayed



Even flat fan nozzle

The **flooding** (flat fan) nozzle delivers a wide-angle flat spray pattern, and are used for applying herbicides and mixtures of herbicides and liquid fertilizers. The nozzle spacing for applying herbicides should be 60 inches or less. These nozzles are most effective in reducing drift when they are operated within a pressure range of 8 to 25 psi. It's pattern is fairly uniform across its width but not as even as the regular flat fan nozzle pattern. If used for broadcast spraying, best distribution is achieved when the nozzle is mounted at a height and angle to obtain at least double coverage or 100-percent overlap.

Flooding nozzles can be mounted so that they spray straight down, straight back, or at any angle in between. Position is not critical as long as double coverage is obtained. You can determine nozzle position by rotating the nozzle to the angle required to obtain double coverage at a practicable nozzle height.

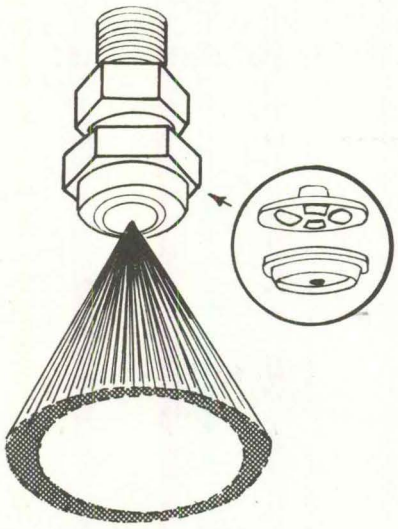


Flooding fan nozzle

Cone Pattern Nozzles

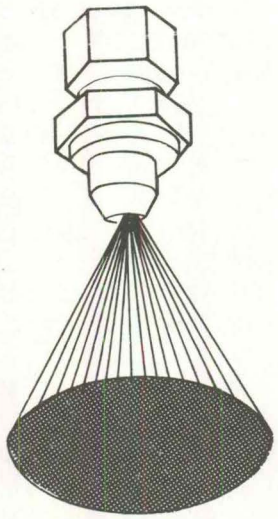
Hollow and solid cone patterns are produced by several types of nozzles. These patterns are used where penetration and coverage of plant foliage or other irregular targets are desired. They are most often used to apply fungicides and insecticides to foliage, although some types are used for broadcast soil applications of herbicides or fertilizers or combinations of the two. When cone pattern nozzles are used for air blast sprayer broadcast application, they should be angled to spray between 15^{o} and 30^{o} from the horizontal and should be spaced to overlap up to 100 percent at the top of the manifold.

The side-entry hollow cone or "whirl-chamber" nozzle produces a very wide angle hollow cone spray pattern at very low pressures. It has a large opening and resists clogging. Because of the wide spray angle, the boom can be operated low, reducing drift. Spacing for double coverage and angling 15^{o} to 45^{o} to the rear is recommended for uniform application. These nozzles may be used in place of flat fan nozzle tips in broadcast applications.



Hollow cone nozzle

Core-insert cone nozzles produce either a solid or hollow cone spray pattern. They operate at moderate pressures and give a finely atomized spray. They should not be used for wettable powders because of small passages which tend to clog and wear rapidly due to abrasion.



Solid cone nozzle

Disc-core nozzles produce a cone-shaped spray pattern which may be hollow or solid. The spray angle depends on the combination of disc and core used and also, to some extent, on the pressure. Discs made of very hard materials resist abrasion well, so these nozzles are recommended for spraying wettable powders at high pressures.

Adjustable cone nozzles change their spray angle from a wide cone pattern to a solid stream when the nozzle collar is turned. Many manual sprayers are equipped with this type of nozzle. Handguns for power sprayers have adjustable nozzles which usually use an internal core to vary the spray angle.

Nozzle Materials

Most nozzle parts are available in several materials. Here are the main features of each kind:

Brass:
* inexpensive,
* resists corrosion from most pesticides,
* wears quickly from abrasion,
* probably the best material for general use,
* liquid fertilizers will corrode.

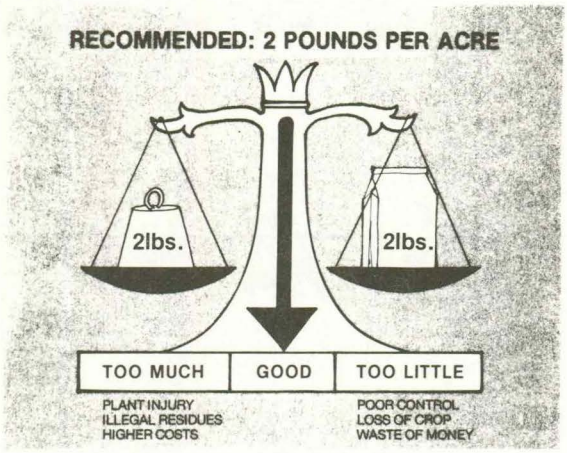
Plastic:
* moderately expensive,
* will not corrode,
* resists abrasion better than brass,
* may swell when exposed to organic solvents.

Stainless Steel:
* moderately expensive,
* resists abrasion, especially if hardened,
* good corrosion resistance,
* suited for high pressures, especially with wettable powders.

Aluminum:
* inexpensive,
* resists some corrosive materials,
* is easily corroded by some fertilizers.

Tungsten Carbide and Ceramic:
* very expensive,
* highly resistant to abrasion and corrosion,
* best material for high pressures and wettable powders.

CALIBRATION



Calibration is the process of measuring and adjusting the amount of pesticide your equipment will apply to the target area. Proper calibration is an essential but often neglected task. You need to be sure you are using the correct amount of pesticide. Too little pesticide can result in inadequate control. Too much pesticide can result in injury to the target plant, animal, or surface; illegal residues; excess runoff or other movement from the target; injury to persons, pets, or wildlife reentering the area; and lawsuits and fines.

Overdosing with pesticides is illegal and carries severe penalties. Another important consideration is the high cost of using the wrong dosage. You may have to repeat the entire application if insufficient pest control results from underdosing. With the high cost of pesticide chemicals, overdosing is very expensive. The key is to take time to calibrate your equipment carefully and correctly. Then check it regularly to detect change due to wear, corrosion, and aging.

Calibration does not have to be difficult. You must be familiar with the operation of the machinery you are using and follow the manufacturer's directions carefully. Pesticide labels and university and professional association recommendations give you much of the information you need in order to calibrate correctly.

Before you begin to calibrate any equipment, check it carefully to be sure that all components are clean and in good working order. The many types of application equipment differ in the details of their operation, but if you understand the basic principles of calibration, you can apply them in any situation. Study the manufacturer's instructions carefully--they explain exactly how to adjust the equipment. They often contain suggestions on such things as the appropriate rate of travel, the range of most efficient pump pressures, approximate settings for achieving various delivery rates; and types of nozzles which can be used.

PRECALIBRATION DECISIONS

Before beginning to calibrate, you need to develop an application strategy. Using your knowledge of the pests to be controlled, the condition and location of the application site, the other pest control methods being used, and the risks and benefits involved, you must choose:

* the pesticide to be applied, and
* the equipment to be used to apply it.

These two factors are closely related. If you have a choice, select the formulation and equipment which is least hazardous to you, other people, and the environment. In any situation, choose equipment which you feel competent to use, and which:

* is designed for the type of chemical being applied, and
* is appropriate for the size and type of application job.

If the equipment you have chosen is not motorized, the calibration may be fairly simple. In fact, some

equipment (such as aerosol cans and hand dusters) does not need any calibration. The pesticide is applied to the point of runoff or is directed at a specific target. You are applying the correct dosage if you have covered the target completely. Other equipment of this type (such as granular spreaders for use on turf) needs to be calibrated only to adjust the delivery rate. This equipment delivers pesticide only when the wheels are in motion, and the speed does not affect the amount of pesticide being deposited per unit area.

If your equipment is motorized, you will need to determine the rate of speed best suited for the type of equipment and for the particular requirements of your application job. The equipment manufacturer's directions may offer a range of appropriate speeds. Your knowledge of factors such as field conditions and drift hazard, plus your experience with the equipment, will help you determine an appropriate speed.

Calibration of Field Sprayers

Three variables affect the amount of spray mixture applied to a unit area (such as an acre or a field or 1,000 square feet of lawn): (1) the nozzle flow rate; (2) the ground speed of the sprayer; and (3) the effective sprayed width per nozzle. To calibrate and operate your sprayer properly, you must know how each of these variables affects sprayer output.

Nozzle Flow Rate

The flow rate through a nozzle varies with the size of the tip and the nozzle pressure. Installing a nozzle tip with a larger orifice or increasing the pressure will increase the flow rate. Nozzle flow rate varies in proportion to the square root of the pressure. Doubling the pressure will not double the flow rate. **To double the flow rate, you must increase the pressure four times.** For example, to double the flow rate of a nozzle from 0.28 GPM at 20 psi to 0.56 GPM, you must increase the pressure to 80 psi (4 x 20 psi).

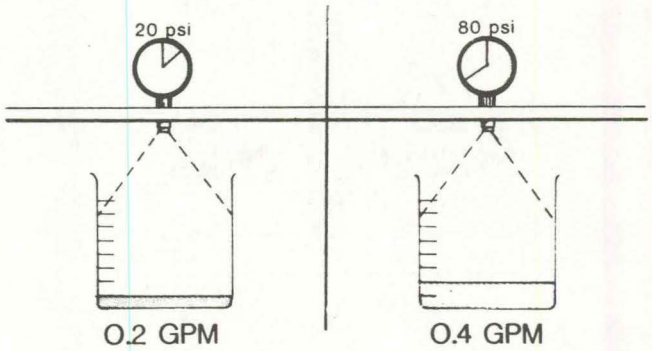


Figure 8. In order to double the output of a nozzle, the pressure must be increased four times.

Pressure cannot be used to make major changes in application rate, but it can be used to correct minor changes because of nozzle wear. To obtain a uniform spray pattern and minimize drift hazard, you must keep the operating pressure within the recommended range for each nozzle type. Remember--if you use check valves to prevent nozzle drip, the pressure at the nozzle is 5 to 7 psi lower than the boom pressure indicated on the pressure gauge.

Ground Speed

The spray application rate varies inversely with the ground speed. **Doubling the ground speed of the sprayer reduces the gallons of spray applied per acre (GPA) by one-half.** For example, a sprayer applying 20 GPA at 3 MPH would apply 10 GPA if the speed were increased to 6 MPH and the pressure remained constant.

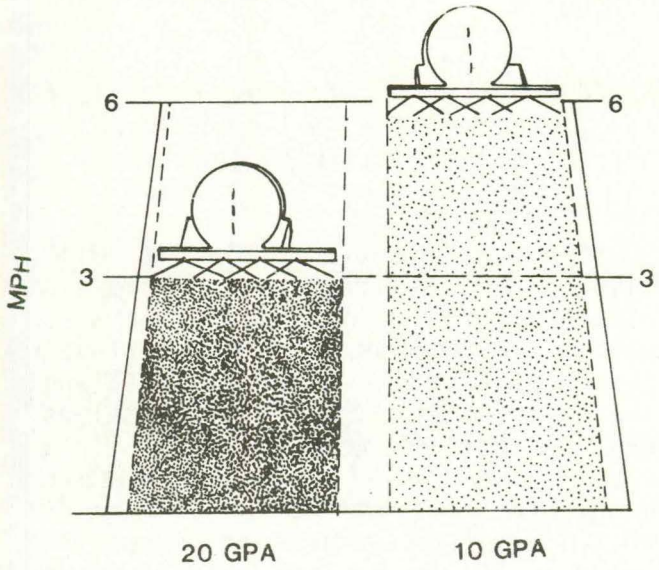


Figure 9. If the output remains the same and the travel speed is doubled the gallons applied per acre decrease by one-half.

Sprayed Width per Nozzle

The effective width sprayed per nozzle also affects the spray application rate. **Doubling the effective sprayed width per nozzle decreases the gallons per acre (GPA) applied by one-half.** For example, if you are applying 40 GPA with flat-fan nozzles on 20-inch spacings, and change to flooding nozzles with the same flow rate on 40-inch spacings, the application rate decreases from 40 GPA to 20 GPA.

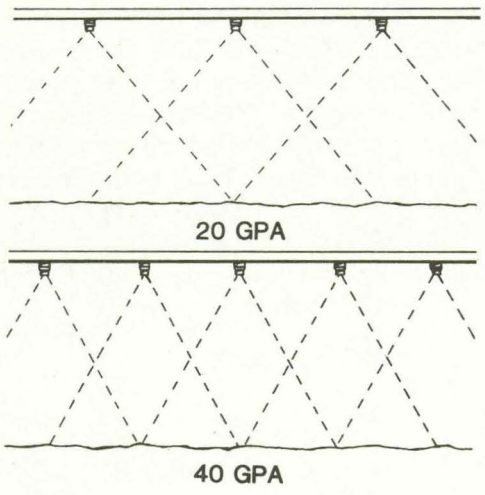


Figure 10. If the number of nozzles on the boom are decreased by one-half, then the GPA are decreased by one-half.

Selecting the Proper Nozzle Tip

The size of the nozzle tip will depend upon the application rate in gallons per acre (GPA), ground speed in miles per hour (MPH), and effective spray width per nozzle (W) that you plan to use. Some manufacturers advertise "gallons-per-acre" nozzles, but this rating is useful only for standard conditions (usually 30 psi, 4 MPH, and 20-inch spacings). The gallons-per-acre rating is useless if any one of your conditions varies from the standard.

A more exact method for choosing the correct nozzle tip is to determine the gallons per minute (GPM) required for your conditions; then select nozzles that provide this flow rate when operated within the recommended pressure range. By following the five steps described below, you can select the nozzles required for each application well ahead of the spraying season.

Step 1. Select the spray application rate in gallons per acre (GPA) that you want to use. Pesticide labels recommend ranges for various types of equipment. The spray application rate is the gallons of carrier (water, fertilizer, etc.) and pesticide applied per treated acre.

Step 2. Select or measure an appropriate ground speed in miles per hour (MPH) according to existing field conditions. Do not rely upon speedometers as an accurate measure of speed. Slippage and variation in tire sizes can result in speedometer errors of 30 percent or more. If you do not know the actual ground speed, you can easily measure it.

To measure ground speed, lay out a known distance in the field to be sprayed or in a field with similar conditions. Suggested distances are:

* 100 feet for speeds up to 5 MPH;
* 200 feet for speeds from 5 to 10

* 200 feet for speeds from 5 to 10 MPH
* 300 feet for speeds above 10 MPH

At the engine throttle setting and gear you plan to use during spraying with a loaded sprayer, determine the travel time between the measured stakes in each direction. Average these speeds and use the following equation to determine travel speed.

$$\text{Speed (MPH)} = \frac{\text{distance (feet)} \times 60}{\text{time (seconds)} \times 88}$$

Example: You measure out a 100-foot course and find it requires 11 seconds for the first pass and 12 seconds for the return pass.

$$\text{Average time} = \frac{11 + 12}{2} = 11.5 \text{ seconds}$$

$$\text{MPH} = \frac{100 \times 60}{11.5 \times 88} = \frac{6000}{1012} = 5.9 \text{ MPH}$$

Once you have decided upon a particular speed, record the throttle setting and drive gear used.

Step 3. Determine the effective sprayed width per nozzle (W) in inches.

For broadcast spraying, W = the nozzle spacing.

For band spraying, W = the band width.

Step 4. Determine the flow rate required from each nozzle in gallons per minute (GPM) by using a nozzle catalog, tables, or the following equation:

$$\text{GPM} = \frac{\text{GPA} \times \text{MPH} \times \text{W}}{5{,}940}$$

GPM = gallons per minute of output required from each nozzle
GPA = gallons per acre from Step 1
MPH = miles per hour from Step 2
W = inches sprayed per nozzle from Step 3
5,940 = a constant to convert gallons per minute, miles per hour, and inches to gallons per acre.

Step 5. Select a nozzle that will give the flow rate determined in Step 4 when the nozzle is operated within the recommended pressure range. You should obtain a catalog listing available nozzle tips. These catalogs may be obtained free of charge from equipment dealers or nozzle manufacturers. The tables on page 81 show the GPM at various pressures for several Spray Systems and Delavan nozzles. If you wish to use nozzles that you already have, return to Step 2 and select a speed that allows you to operate within the recommended pressure range.

Example 1: You want to broadcast a herbicide at 15 GPA (Step 1) at a speed of 7 MPH (Step 2), using flooding nozzles spaced 40 inches apart on the boom (Step 3). What nozzle tip should you select?

The required flow rate for each nozzle (Step 4) is as follows:

$$\text{GPM} = \frac{\text{GPA} \times \text{MPH} \times \text{W}}{5{,}940}$$

$$\text{GPM} = \frac{15 \times 7 \times 40}{5{,}940} = \frac{4{,}200}{5{,}940} = 0.71$$

The nozzle you select must have a flow rate of 0.71 GPM when operated within the recommended pressure. The tables on page 81 show the GPM at various pressures for several nozzles. Spraying Systems TK5 and Delavan D5 nozzles have a rated output of 0.71 GPM at 20 psi (Step 5). Either of these nozzles can be purchased for this application.

Table 2. Typical Nozzle Catalog Data for Flooding Flat Fan Nozzles

Spraying Systems

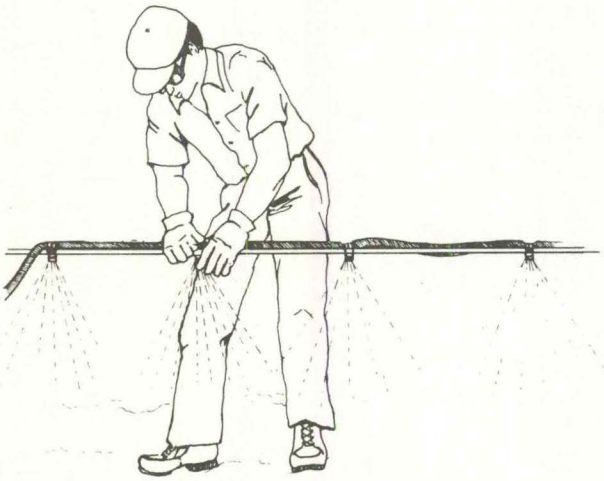
Flood Jet Tip No.	Flood Jet Nozzle No. see page 11	Liquid in p.s.i.	Capacity in G.P.M.
TK.50 (100 Mesh)	1/8K.50	10 20 30 40	– .07 .08 .10
TK.75 (100 Mesh)	1/8K.75	10 20 30 40	.075 .11 .13 .15
TK1 (100 Mesh)	1/8K1	10 20 30 40	.10 .14 .17 .20
TK1.5 (50 Mesh)	1/8K1.5	10 20 30 40	.15 .21 .26 .30
TK2 (50 Mesh)	1/8K2	10 20 30 40	.20 .28 .35 .40
TK2.5 (50 Mesh)	1/8K2.5	10 20 30 40	.25 .35 .43 .50
TK3 (50 Mesh)	1/8K3	10 20 30 40	.30 .42 .52 .60
TK4	1/8K4	10 20 30 40	.40 .57 .69 .80
TK5	1/8K5	10 20 30 40	.50 .71 .87 1.0

Delavan

NOZZLE NUMBER		Pressure (PSIG)	Capacity 1-Nozzle (GPM)
D-Tip	Nozzle		
D.5	F.5 1/8"	10 20 30 40	.050 .071 .087 .10
D.75	F.75 1/8"	10 20 30 40	.075 .11 .13 .15
D1	F1 1/8"	10 20 30 40	.10 .14 .17 .20
D1.5	F1.5 1/8"	10 20 30 40	.15 .21 .26 .30
D2	F2 1/8"	10 20 30 40	.20 .28 .35 .40
D2.5	F2.5 1/8" & 1/4"	10 20 30 40	.25 .35 .43 .50
D3	F3 1/8" & 1/4"	10 20 30 40	.30 .42 .52 .60
D4	F4 1/8" & 1/4"	10 20 30 40	.40 .57 .69 .80
D5	F5 1/8" & 1/4"	10 20 30 40	.50 .71 .87 1.0

Precalibration Checking

After making sure that your sprayer is clean, install the selected nozzle tips, partially fill the tank with clean water, and operate the sprayer at a pressure within the recommended range. Place a container (for example, a quart jar) under each nozzle. Check to see whether all of the jars fill at about the same time. Replace any nozzle that has an output of 5 percent more or less than the average of all the nozzles, an obviously different fan angle, or a nonuniform appearance in spray pattern.



To obtain uniform coverage, you must consider the spray angle, spacing, and height of the nozzle. The height must be readjusted for uniform coverage with various spray angles and nozzle spacings. Do not use nozzles with different spray angles on the same boom for broadcast spraying.

Worn or partially plugged nozzles produce non-uniform patterns. Misalignment of nozzle tips is a common cause of uneven coverage. The boom must be level at all times to maintain uniform coverage. Skips and uneven coverage will result if one end of the boom is allowed to droop. A practical method for determining the exact nozzle height that will produce the most uniform coverage is to spray on a warm surface such as a road and observe the drying rate. Adjust the height to eliminate excess streaking.

Calibrating Your Sprayer

Now that you have selected and installed the proper nozzle tips, you are ready to complete the calibration of your sprayer. Check the calibration every few days during the season or when changing the pesticides being applied. New nozzles do not lessen the need to calibrate because some nozzles "wear in," and will increase their flow rate most rapidly during the first few hours of use.

There are many ways to calibrate equipment. The preferred methods differ according to the kind of equipment used. Here is one basic method that will allow calibration in a minimum amount of time for either broadcast or band application:

Step 1. First, fill the sprayer tank at least half full of water. This will simulate actual spraying conditions.

Step 2. Determine the nozzle spacing or band width in inches and measure the appropriate distance in the field according to the following table:

Broadcast nozzle spacing or band width (inches)	Travel distance (feet)
7	583
14	408
20	204
30	136
36	113
38	107
40	102

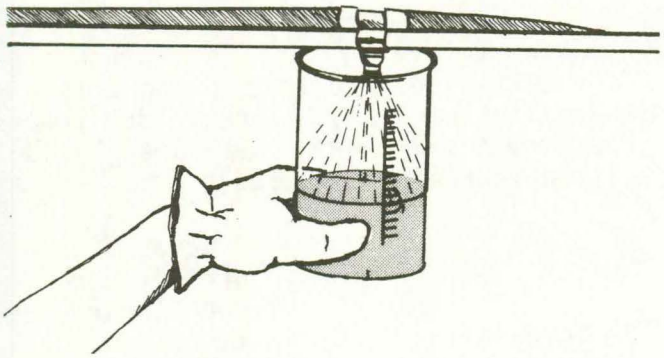
If you are banding a pesticide, remember to determine your travel

distance by the band width instead of nozzle spacing.

Step 3. In the field, measure and stake the distance to be traveled. Select the tractor gear and mark the throttle or speedometer setting to be used during the spraying operation. Start the tractor 25 feet behind the starting point and start timing when crossing the start line. Stop timing at the designated distance. Record the travel time in seconds.

Step 4. Set the pressure at the reading to be used to spray the field.

Step 5. With the sprayer stationary and with just water in the sprayer tank, collect water from each nozzle at the pre-set pressure for the number of seconds it took to travel the prescribed distance. If there is more than a 5 percent variation from the average, the nozzle tip should be changed.



Step 6. The ounces collected per nozzle equal the number of gallons per acre the sprayer will produce.

ounces per nozzle = gallons per acre

Step 7. The sprayer is calibrated. Next, determine the amount of pesticide to add to the spray tank. Know the recommended rate of chemical application, the capacity of the spray tank, and the calibrated output of the sprayer.

The examples below do not imply endorsement of a particular product or brand name.

Example: In broadcast application, Lasso will be applied at the rate of 3 quarts per acre. The sprayer has a 200-gallon tank and is calibrated to apply 20 gallons per acre.

Determine the number of acres that can be sprayed with each tankful:

$$\text{Acres per tankful} = \frac{\text{tank capacity}}{\text{spray rate}}$$

$$= \frac{200}{20}$$

$$= 10 \text{ acres}$$

Determine the amount of pesticide to add to each tankful:

Amount per tankful =
acres per tankful x rate per acre =

10 x 3 = 30 quarts

30 quarts of Lasso must be added to each tankful applied.

Example: A farmer has corn rows 38 inches apart. He wants to apply a herbicide at the rate of 2 qt./A but in a 14 inch band, to 120 acres. His sprayer is calibrated to apply 30 GPA. The tank capacity is 300 gallons.

Determine the actual number of acres to be treated and the amount of herbicide necessary:

$$120 \text{ acres} \times \frac{14 \text{ inches/band}}{38 \text{ inches/row}} = \frac{1680}{38}$$

= 44.2 acres to treat

2qt./A x 44.2 acres = 88.4 qts. of herbicide needed.

The concentration of pesticide in each band is the same as a broadcast

application. The only difference is that since you are not spraying the entire area you will have to drive over more than one acre of land in order to use "one acre's worth" of spray solution

Determine the number of acres that can be sprayed with each tankful:

$$\text{Acres per tankful} = \frac{\text{tank capacity}}{\text{spray rate}}$$

$$= \frac{300}{30}$$

$$= 10 \text{ acres}$$

Determine the amount of pesticide to add to each tankful:

Amount per tankful =
acres per tankful x rate per acre =

10 acres x 2 qts. = 20 quarts/tankful

Calibration of Granular Applicators

The application rate of granular applicators depends on the size of the metering opening, the speed of the agitator or rotor, travel speed, the roughness of the field, and the flowability of the granules. Granules flow at different rates depending on size, density, type of granule, temperature, and humidity. A different applicator setting may be necessary for each pesticide applied; variations in flow rate can also occur with the same product from day to day or from field to field. It is, therefore, important to calibrate frequently in order to maintain the proper application rate.

Apart from the actual setting of the metering opening, ground speed is the most significant factor affecting the application rate. The ground speed during calibration and application must be the same, and the speed must remain constant. Even though gravity-flow applicators use a rotating agitator whose speed varies with ground speed, the flow of granules through the opening is not necessarily proportional to speed. A speed change of one mile per hour may cause a significant variation in the application rate.

It is important to keep in mind that, in addition to affecting the flow rate, high humidity may cause clumping of some granules leading to a nonuniform application and, in some cases, to actual clogging of the equipment.

The method chosen for calibrating a granular applicator depends largely on the type of equipment and method of application, as well as the way in which the application rate is expressed. The following method is simple and will allow calibrating for granular insecticides in a 7-inch band width or for infurrow applications. This method is only applicable for insecticides applied at the rate of 1 pound active ingredient per 13,068 linear-foot row.

Step 1. Measure and mark a distance of 1,000 feet in the field.

Step 2. Based on the granular formulation applied at 1 pound active ingredient per 13,068 linear-foot row, the amount of insecticide to apply is listed in the table below.

Formulation	Ounces of product per 1,000 linear ft of row
10 G	12.2 oz
15 G	8.2 oz
20 G	6.1 oz

Step 3. Fill the hoppers, turn the applicator on, and operate them until all are feeding. The turn them off, disconnect the drop tubes and attach a container (e.g. plastic bag or plastic jar) to the outlet of each applicator;

the weight of each container must be known unless it is negligible. Calibration must be done with the same brand granules that will be used during application.

Step 4. Drive the measured distance, operating at the speed that will be used during application.

Step 5. Weight and record the amount of material collected from each hopper. Compare this weight with the recommended application rate. Adjust the setting of any unit that is not within 5 percent of the recommended rate and recalibrate.

Additional information on spraying equipment and calibration is in the following publications available from county extension offices or from Publications Distribution, Iowa State University, Ames, Iowa 50011.

Pm-1101a, Spraying Equipment--Nozzles; Pm-1101b, Spraying Equipment--Pumps, Pm-1101c, Spraying Equipment--Tanks and Agitators; Pm-1101d, Spraying Equipment--Strainers, Booms, Flow Control Devices; Pm-617, Pesticide Calibration

Laws and Regulations

Approximately 1.2 billion pounds of pesticides are sold each year. About 70 percent of all pesticides used are applied in agricultural production, 7 percent in home and garden settings, and the remaining 23 percent in forestry, industry and government programs.

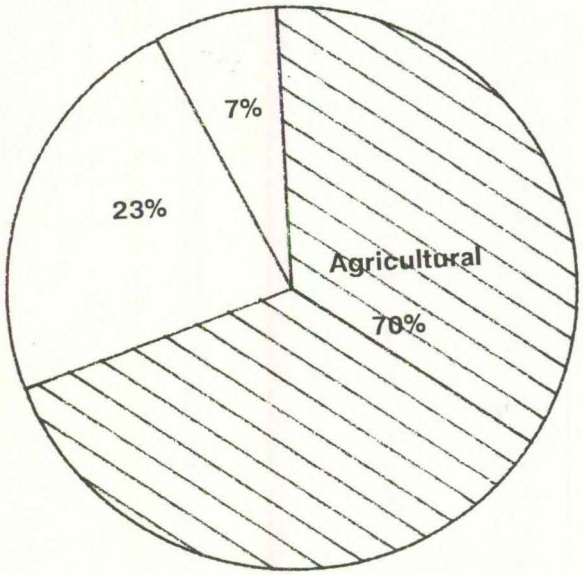


Figure 11. Pesticide use in the U.S.

In recent years, there has been a growing concern about the extensive use of pesticides. There is widespread fear about the possible harmful effects of pesticides on humans, wildlife, and environment. There is increased awareness of potential health problems that may result from pesticide exposure. The public is concerned about the presence of pesticides in our surface and groundwater and about the tolerances established for pesticides in our food. Consequently, laws and regulations have been adopted to help protect the public, the environment, and the pesticide applicator.

Federal Regulations

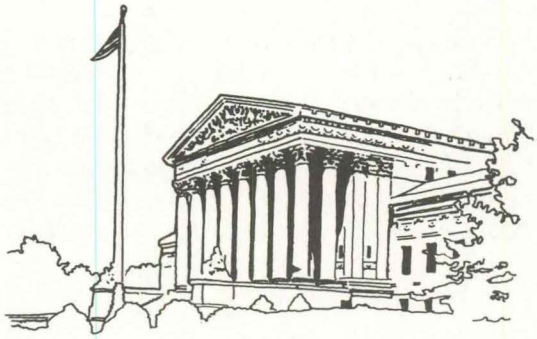
The United States Environmental Protection Agency (EPA) is responsible for pesticide regulation. EPA carries out the regulations established under two federal laws:

1. Federal Insecticide, Fungicide, and Rodenticide Act (FIFRA) - governs the registration, manufacture, transportation and use of pesticides.

2. Federal Food, Drug and Cosmetic Act (FFDCA) - governs pesticide residue levels in food or feed crops.

FIFRA

FIFRA was originally passed by Congress in 1947. Since then it has been amended several times, with substantial changes made in 1972, 1974 and 1978.



Pesticide Registration

Every pesticide that is bought, sold, or used in the United States must, by law, be registered by the EPA. EPA approves not only the product and it's label, but also each separate use for which it is intended. Approximately 45,000 pesticide products are currently marketed in the United States. There are about 1,400 active ingredients in the 45,000 products currently on the market.

EPA bases its registration decisions for new pesticides on its evaluation of test data provided by the applicants. Required studies

include testing to show whether a pesticide has the potential to cause adverse effects in humans, fish, wildlife, and endangered species. Potential human risks include acute reactions such as toxic poisoning and skin and eye irritation, as well as possible long-term effects like cancer, birth defects, or reproductive disorders. Data on how the pesticide behaves in the environment are also required, so that EPA can determine if a pesticide poses a threat to ground or surface water.

The registration process takes two to three years and the estimated cost for a pesticide manufacturer to meet EPA's registration data requirements is between $2 to $4 million.

In addition to federal registration, FIFRA provides two methods for special registration of pesticides: Special Local Need and Emergency Exemption from Registration.

Special Local Need Registration, known as 24c or SLN registration, allows a state to register additional uses for a federally registered pesticide. In Iowa this registration is requested by the pesticide manufacturer and approved by the Iowa Department of Agriculture and Land Stewardship. The approving state must show that there is a local need for the pesticide and that the pesticide is more effective or less hazardous than the currently registered products. The duration for this special label is 5 years. The company must provide supplemental labeling for each SLN registration. The applicator must possess a copy of the SLN label in order to apply the pesticide for that purpose.

Emergency Exemption from Registration Section 18, is requested by the Iowa Secretary of Agriculture and Land Stewardship and approved by the EPA. The state must show that a pest outbreak has or is about to occur and no pesticide is registered that can provide control. This registration allows for the sale and use of a pesticide for a non-registered purpose for a limited time, usually less than 1 year.

Classification of Pesticides

When each pesticide is registered with EPA, its uses must be classified as either general or restricted use.

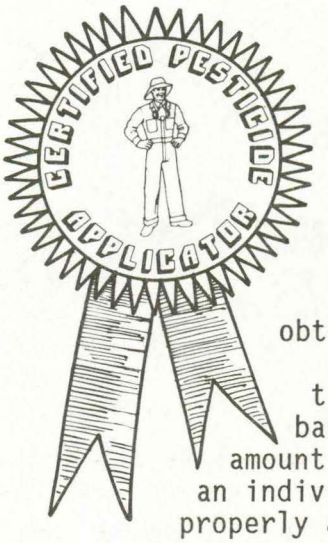
Pesticide uses that will damage humans or the environment very little or not at all when applied as the label directs can be classified as general use under current law.

Uses that could cause human injury or environmental damage even when applied as directed on the label must be classified as restricted use. These uses may be carried out only by someone who is certified.

Some pesticides may be classified as general use under some applications and restricted use for others.

When a pesticide is restricted, the label will say "Restricted Use Pesticide" in a box on a prominent part of the label. When a pesticide is classified for general use, the words, "General Classification" will appear immediately below the heading "Direction for Use".

Certification of Applicators



As a result of FIFRA, the pesticide applicator training program was developed to enable pesticide applicators to obtain certification. The certification training program is based on the minimum amount of knowledge that an individual must have to properly apply a pesticide.

In order to demonstrate competency pesticide applicators must possess practical knowledge in the areas of laws and regulations, pesticide labels and labeling comprehension, pesticide safety, human health and environmental considerations, pests, pesticides, pesticide application equipment, pesticide equipment calibration, pesticide transportation, storage and disposal and Integrated Pest Management.

In addition, commercial and public applicators must exhibit competency in those areas or categories of pest control that they plan to make pesticide applications. In Iowa there are 18 different categories in which applicators may be certified.

See page 93 for information on how to become a certified commercial pesticide applicator in Iowa.

Application Inconsistent with Label

Pesticides must be used only according to label directions. An applicator may not use any pesticide in a manner not permitted by the label. You must use the pesticide only on the plants, animals, or sites specified in the directions for use. You may not use higher dosages, higher concentrations, or more frequent applications. You must follow the label directions for use, safety, mixture, dilution, storage, and disposal - as well as restrictions on reentry or days to harvest, slaughter, and grazing.

Amendments made to FIFRA in 1978 allowed for some deviation from the label. IF, however, any problems result because of these uses, the applicator alone is responsible for the consequences. There are five exceptions when an applicator can deviate from the label:

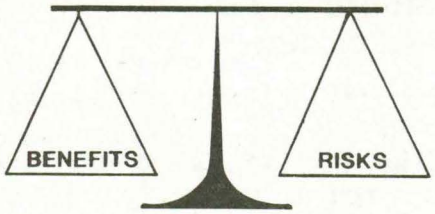
1. Application of a pesticide in any dosage, concentration, or frequency less than that listed on the label.
2. Application of a pesticide against any target pest not listed on the labeling if the application is to a crop, animal, or site that is listed.
3. Use of any equipment or method of application that is not prohibited by the labeling.
4. Mixing of a pesticide or pesticides with a fertilizer if the mixture is not prohibited by the label.
5. Mixing two or more pesticides if all the dosages are at or below the recommended rate if the mixture is not prohibited by the label.

Reregistration

In addition to regulating new pesticides, EPA is charged with protecting human health and the environment from any unreasonable adverse effects associated with pesticides already registered and in use. EPA carries out this directive by requiring the "reregistration" of all existing pesticides. This reregistration ensures that previously registered pesticides meet current scientific and regulatory standards.

Also, whenever data on a registered pesticide indicate that it may be representing unreasonable risks, EPA initiates a public **"Special Review"** to determine whether regulatory action is warranted.

Special review is a process that provides a risk/benefit analysis of pesticides for which legitimate questions of use have been raised.



Special review leads to a decision to take no action against the product, to restrict some or all use of the product, or to initiate cancellation of the product. A number of pesticides are or have been in the special review process including Bladex, Lasso, captan, Furadan, Endrin, chlordane, and Heptachlor.

PENALTIES

Violation of the legal provisions established in FIFRA may bring about civil penalties that can be as much as $5,000 for each offense. Before an EPA fine is levied, you have the right to ask for a hearing in your own city or county. Violation of the law may also subject one to criminal penalties that can be as much as $25,000 or 1 year in prison, or both.

EPA Levies Strict Fines on Violators

The EPA accused an uncertified applicator in Kansas of 45 counts of using "restricted use" compounds in grain elevators and feed lots. He was fined $115,000. A Nebraska exterminator company was fined $35,000 for illegal use of "restricted use" products. A Colorado aerial applicator was fined $14,200 for misuse, improper application of "restricted use" pesticides and failure to keep proper records. A Nevada firm was fined $21,850 for 21 counts of sales of "restricted use" pesticides to uncertified applicators.

FFDCA

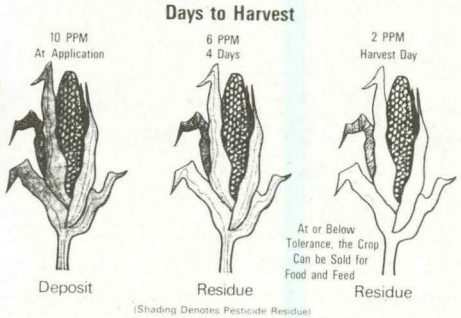
EPA sets residue tolerances under regulations authorized by the Federal Food, Drug and Cosmetic Act (FFDCA). The pesticide that stays in or on raw farm products or processed foods is called a residue. Residues in processed foods are considered to be food additives and are regulated as such.

Pesticide residues are measured in parts per million (ppm). One ppm equals one part (by weight) of pesticide for each million parts of farm or food product. Using pounds as a measure, 50 ppm would be 50 pounds of pesticide in a million pounds of product.

If too much residue is found on a farm or food product, the product may be seized or condemned by the Iowa Department of Agriculture and Land Stewardship.

Tolerance is the concentration of pesticide residue that is judged to be safe for human consumption. The same pesticide may have a different tolerance on different products.

The label will state the **harvest interval**, or how many days before harvest the pesticide may be applied. Pesticides applied shortly before harvest may leave residues that will exceed the set tolerance limit. Follow the label exactly to avoid breaking the law.



Other Federal Agencies and Regulations

Department of Transportation

Shipment of pesticides and other dangerous substances across state lines is regulated by the Federal Department of Transportation (DOT). DOT issues the rules for hauling these materials.

DOT standards specify which pesticides are dangerous to people and create a health hazard during transportation.

If you ever haul pesticides between states, you should know that:

- They must be in their original packages. Each package must meet DOT standards.
- The vehicle must have a correct sign. Manufacturers must put the correct warning signs on each package.
- The pesticides may not be hauled in the same vehicle with food products.
- You must tell DOT about all spills during shipment.

Federal Aviation Administration

Application of pesticides from airplanes is regulated by the Federal Aviation Administration (FAA) and may be regulated by individual states. FAA judges both the flying ability of the pilots and the safety of their aircraft. FAA rules say that an aerial applicator may not apply any pesticides except as the label directs.

Occupational Safety & Human Health Act

The Occupational Safety and Health Act of 1970 is administered by the Occupational Safety and Health Administration (OSHA) in the Department of Labor (DOL). It requires anyone with 11 or more workers to keep records and make reports. The records must include all work-related deaths, injuries, and illnesses. Minor injuries needing only first aid treatment need not be recorded. But a record must be made if the injury involves medical treatment, loss of consciousness, restriction of work or motion, or transfer to another job.

RCRA

The Resource Conservation and Recovery Act (RCRA) of 1972 gives EPA authority to control the disposal of hazardous wastes. The EPA defines "hazardous waste" as solid wastes, including liquids and gases, that when mismanaged may cause death or injury or pollute the environment. A waste is considered hazardous if it is included on the EPA lists, or if it is highly flammable, corrosive, reactive or is likely to contaminate the groundwater. Most pesticides are categorized as hazardous waste because of their toxicity.

Applicators who use pesticides on the hazardous waste list may be affected by RCRA regulations. (Table 3 in the appendix lists the pesticides included on the hazardous and acutely hazardous waste list.) The type and quantity of waste

generated determines which RCRA provisions apply. If quantities generated are below the Small Quantity Generator levels, hazardous waste must be disposed of properly. Currently, Iowa has no Hazardous waste disposal facilities.

A farmer disposing of pesticides that are hazardous wastes is not required to register as a generator of hazardous waste provided that he or she triple-rinses each emptied pesticide container and disposes of the pesticide residues on his or her own farm in a manner consistent with the disposal instructions on the pesticide label.

A pesticide becomes a hazardous waste when the product is no longer usable as a pesticide or is destined for disposal. A pesticide container becomes a hazardous waste when it is not triple rinsed. Accidental spills, unrinsed containers, debris from a pesticide storage fire, damaged products (broken emulsions, caked wettable powders, etc.), and pesticide rinsate are all considered hazardous waste.

There are three cateogories of hazardous waste generators:

Category 1. Generators of no more than 100 kilograms (220 pounds) of hazardous waste per month; and no more than 1 kilogram (2.2 pounds) of acutely hazardous waste per month.

Federal regulations require you to identify all hazardous waste you generate; send this waste to a hazardous waste facility; and never accumulate more than 1000 kilograms of hazardous waste on your property. (If you do, you become subject to all the requirements applicable to 100-1000 kilograms per month generators.)

Category 2. Generators of more than 100 and less than 1000 kilograms (220 to 2,200 pounds) of hazardous waste and no more than 1 kilogram of acutely hazardous waste per month.

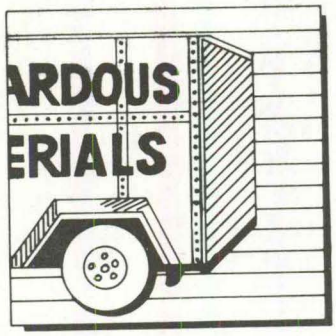
Category 3. Generators of 1000 kilograms or more of hazardous waste, or more than 1 kilogram of acutely hazardous waste in one month.

If you fall under Category 2 or 3 (generate more than 100 kilograms of hazardous waste per month) you must comply with the following regulations:

1. Register with the U.S. EPA and obtain an identification number as a Hazardous Waste Generator (request form 8700-12 from the U.S. EPA Region VII, RCRA Activities, Kansas City).

2. Obtain a treatment, disposal and storage facility permit, if you treat or accumulate certain amounts of waste for more than 90 days.

3. Label containers properly; keep records of shipments; use only transporters with an EPA identification number, comply with proper DOT shipping procedures and placarding; assure that the waste reaches the disposal facility; and submit an annual summary of activities.



You will not be regulated by the federal hazardous waste law if you can follow one or more of the guidelines listed below.

* Do not use any pesticide on the hazardous waste list.

* Do not treat, store or dispose of, a quantity that exceeds the limits established by the EPA and follow proper procedures for disposal of small quantities.

* Triple rinse noncombustible containers with ample quantities of water. Remove all pesticide possible from any noncombustible containers by opening both ends to help remove remaining pesticide and to prevent reuse of the container.

  Containers that have held acute hazardous waste must be triple rinsed using a solvent capable of removing the chemical product.

* Apply any excess pesticide and rinsate according to label instructions.

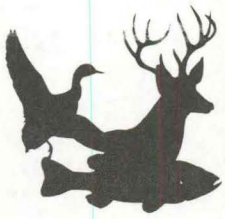
If you have questions about this act, contact:

U.S. Environmental Protection Agency - Iowa Section
726 Minnesota Avenue
Kansas City, Kansas 66101
913/236-2887

A toll-free action line for EPA may be reached at 800/223-0425. The action line staff will take a message and request that the appropriate EPA personnel contact you.

Endangered Species Act (ESA)

By 1988 many pesticide products will have labels modified to comply with the federal Endangered Species Act. The goal of this legislation is to provide protection for threatened and endangered species. The label changes are designed to protect specific endangered species from adverse effects of pesticides. The products affected in 1988 will be mosquito larvicides and pesticides used on cropland (corn, cotton, soybeans, sorghum and small grains), pasture and rangeland, and forests.



The new labels will list the state and county where endangered species restrictions apply. Pesticide users will be required to obtain, and comply with, a county-specific endangered species bulletin. This bulletin will include a county map identifying the range of land inhabited by species placed in jeopardy by specific pesticides, the specific pesticides listed by active ingredient, and a list of endangered species that have ranges in that county. The endangered species bulletin will be available at county extension offices, pesticide dealers and other outlets. The U.S. Fish and Wildlife Service is the ultimate authority on endangered species.

At this time, Iowa counties that have been identified as containing habitats of endangered species are: Allamakee, Butler, Clarke, Clayton, Clinton, Des Moines, Dickinson, Dubuque, Emmet, Fayette, Howard, Jackson, Kossuth, Louisa, Lucas, Muscatine, Osceola, Scott, Story, and Winneshiek.

Federal Emergency Planning and Community Right-to-Know Act of 1986

Refer to page 99 for further information on this regulation.

State Regulations and Agencies

Iowa Pesticide Act

The Iowa Pesticide Act was amended in 1975 to comply with the pesticide applicator certification requirements of FIFRA. In 1977 the state Legislature passed further amendments to the Pesticide Act. These amendments eliminated the testing requirements for private applicators, requiring instead that individuals attend a pesticide applicator certification training session conducted by the ISU Cooperative Extension Service. Additionally, the recertification examination requirement for commercial pesticide applicators was eliminated, allowing recertification by attendance at an approved training session conducted by the ISU Cooperative Extension Service.

The state Legislature amended the Iowa Pesticide Act again in 1987. The initial testing requirement for private pesticide applicators and the recertification examination for commercial and public pesticide applicators were reinstated.

The 1987 amendments eliminated pesticide application by a noncertified applicator working under the direct supervision of a certified pesticide applicator. Previously private pesticide applicators could supervise noncertified hired hands or family members who were applying restricted use pesticides. Commercial pesticide applicators could supervise noncertified employees applying products. Application of pesticides "under the direct supervision" of a certified applicator is no longer allowed.

The 1987 amendments also require that commercial or public applicators notify owners of adjoining properties prior to or after an exterior pesticide application in an urban area and prior to the application of herbicides to noxious weeds or undesirable vegetation within highway right-of-ways.

How to Become Certified to Apply Pesticides in Iowa

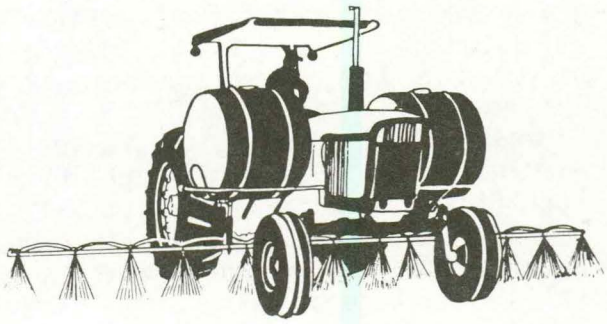
Private Applicators

Private applicators are persons who apply any restricted use pesticide for the production of an agricultural commodity on property owned or rented by themselves or their employers, or on the property of other persons with whom they trade services. Therefore, there are 2 criteria for qualification as a private applicator:

1. Application must occur on land under that persons control, or that of his/her employer.

2. No money changes hands as a result of the application.

An individual employed by a farmer, for purposes other than pesticide application, who applies a restricted use pesticide as an incidental part of his/her duties or as a part of a custom farming operation is required to be certified as a private applicator.



All private applicators who wish to purchase and/or apply, restricted use pesticides must be certified. It is no longer legal for certified private pesticide applicators to supervise a non-certified individual applying restricted use pesticides. Private applicators who apply only general use pesticides do not have to be certified. There are no requirements for private applicators wishing to apply general use pesticides.

Starting in 1987 all private applicators must pass an exam demonstrating their knowledge of safe handling of agricultural pesticides and pest control practices.

Training and Testing. To prepare for the exam, study the Private Pesticide Applicator Study Guide and attend a training session provided by the Cooperative Extension Service. Check with your county extension office for information on training and testing dates in your area. Study guides are available at your county extension office or from Publications Distribution, Iowa State University, Ames, Iowa, 50011.

Upon successful completion of the certification examination with a grade of 70 percent or better, each applicator will pay a $5 certification fee to the Iowa Department of Agriculture and Land Stewardship and receive a private pesticide applicator certification card. This card must be presented to the pesticide dealer to buy any restricted use pesticides.

A private applicator who uses any grain fumigant classified restricted use, must meet the commercial certification requirements for Fumigation, Category 7C. Upon successfully completing the Fumigation examination, the private applicators certification card will indicate it.

Recertification. Certification is valid for three years. Individuals holding current private pesticide applicator certifications expiring in 1987 or individuals needing initial certification must obtain certification by passing the exam. Once certification has been obtained by examination, private pesticide applicators may renew their certification by attending a training session conducted by the ISU Cooperative Extension Service within the 12 months before or the four months after the expiration date on the certification card or by re-examination. If the certification is allowed to expire, the applicator will have to pass the certification examination again.

Commercial and Public Applicators

Commercial and public applicators are persons who apply pesticides or utilize pest controlling devices for hire on property other than their own.

Commercial and public pesticide applicators must pass an examination demonstrating competence in applying pesticides before receiving a pesticide applicator certification card and before a pesticide applicator's license is issued to the company.

Commercial and public applicators are trained and tested in the safe use and handling of pesticides, as discussed in this manual, and then receive further training and testing in one or more specific Categories of Application, including:

Category 1A - Agricultural Weed Control. Persons applying herbicides to corn, soybeans, small grains, forages, grassland, etc.

Category 1B - Agricultural Insect Control. Persons applying insecticides to corn, soybeans, small grains, forages, grassland, etc.

Category 1C - Agricultural Disease Control. Persons applying fungicides to corn, soybeans, small grains, forages, grassland, etc.

Category 1D - Fruit & Vegetable Pest Control. Persons applying pesticides to fruit and vegetable crops.

Category 1E - Animal Pest Control. Persons applying pesticides on animals and to places on or in which animals are confined.

Category 2 - Forest Pest Control. Persons applying pesticides to forests, forest nurseries and forest seed-producing areas.

Category 3 - Ornamental, Turf & Greenhouse Pest Control

1. Ornamental Pest Control - Persons applying pesticides to trees, shrubs, and flowers.
2. Turf Pest Control - Persons applying pesticides to turfgrass and sod.
3. Greenhouse Pest Control - Persons applying pesticides in greenhouses.

Category 4 - Seed Treatment. Persons applying pesticides to seed.

Category 5 - Aquatic Pest Control. Persons applying herbicides to control weeds in standing or running water. Excludes applicators engaged in public health pest control programs.

Category 6 - Right-of-Way Pest Control. Persons applying pesticides to right-of-ways, roadsides, electric powerlines, pipelines, railroads, etc.

Category 7A - General & Household Pest Control. Persons applying pesticides in human dwellings, institutions, food dispensing and handling establishments, including food manufacturers and processors.

Category 7B - Termite Pest Control. Persons applying pesticides for structural pest control.

Category 7C - Fumigation. Persons applying fumigants in, on or around areas where grain is stored, where food is processed or manufactured or produced and in storage structures, greenhouses and dwellings.

Category 7D - Community Insect Control. Persons applying pesticides for the control of flies and mosquitoes in community health programs.

Category 8 - Public Health Pest Control. Persons applying pesticides in public health programs for the management and control of insects, disease, rodents, and birds having medical and public health importance.

Category 9 - Regulatory Pest Control. Government employees applying pesticides to control pests as a part of their regulatory responsibilities.

Category 10 - Demonstration & Research Pest Control. Persons demonstrating safe and effective use of pesticides to the public; persons associated with research on pesticides, including determining the effectiveness of pesticides, residue problems, effect on nontarget organisms, etc. To become certified in this category, individuals must also be certified in an additional category. This category includes cooperative extension staff, industry representatives, researchers, vocational agriculture teachers, and others.

Because of the use of categories of application it may be necessary for an applicator to become certified in more than one category in order to legally apply pesticides. A different examination is given for each category. A person can obtain certification as an applicator in several categories, depending upon his/her work. There is no extra charge for certification in more than one category.

Any person engaged in aerial applications of pesticides must obtain certification in each appropriate category for the area(s) of application desired. For example, an aerial applicator who applies herbicides and sprays for mosquitoes would have to be certified in Category

1A - Ag Weed Control and in Category 7D - Community Insect Control.

Any person applying pesticides to research and demonstration plots must be certified in each appropriate category and in Category 10 - Research and Demonstration.

Certification Fee. Each commercial pesticide applicator and public pesticide applicator must pay a certification fee to the Iowa Department of Agriculture and Land Stewardship each time he/she is certified.

The commercial and public applicator may choose between a one year certification for $25 or a three year certification for $75. Employees of state agencies may choose between a $5 annual certification fee or a $15 fee for a three year certification.

Training & Testing. To prepare for written examinations, study this manual as well as the appropriate category manual(s). These manuals can be obtained from county extension offices or from Publications Distribution, Iowa State University, Ames, Iowa 50011. When ordering a category manual from Publications Distribution, give the specific category number and check prices before ordering.

Training sessions are provided by the ISU Cooperative Extension Service to help individuals prepare for the examinations. Check with your county extension office for information on training sessions being offered in your area.

Written examination(s) may be taken on any weekday, Monday through Friday, that state offices are open, preferably before 3 p.m. No appointment is needed and there is no charge for taking the examination(s). The Pesticide Section of the Iowa Department of Agriculture and Land Stewardship is in the Wallace State Office Building, 900 East Grand Ave., Des Moines, Iowa 50319.

Written exams will also be given in the outlying areas of the state each year. Pesticide applicators should keep in touch with their local county extension offices for specific dates and places.

The Core Manual exam has 50 multiple choice questions. At least 40 questions must be answered correctly to pass. Each category exam has 35 multiple choice questions, with a least 28 correct answers needed to pass. A person who fails an exam will not be able to repeat it on that same day. Individuals will be allowed three attempts to pass each examination.

If a person passes only some of the exams taken, the Department of Agriculture and Land Stewardship will keep those scores on record for about a year. Therefore, repeat exams are needed only on those previously failed. It is not necessary to repeat the entire series.

Recertification The Iowa Department of Agriculture and Land Stewardship requires recertification of commercial, public, and noncommercial pesticide applicators when their certification expires. Recertification is obtained by passing the Iowa Core Manual examination as well as the appropriate category examination(s).

Continuing Education Requirements. In 1986 the Legislative Rules Committee passed a Continuing Education

Requirement for commercial pesticide applicators. All commercial and public pesticide applicators must obtain six contact hours of continuing education each year. Continuing education forms will be provided for each participant at training sessions approved by the Iowa Department of Agriculture and Land Stewardship. It is the responsibility of the pesticide applicator to keep his/her continuing education forms on file. When the company pesticide applicator license is renewed each year, the continuing education forms for all commercial pesticide applicators working for the company, must be sent to the Iowa Department of Agriculture and Land Stewardship.

Recordkeeping. The Iowa Pesticide Act requires that commercial, public and noncommercial pesticide applicators maintain records of each pesticide applied for three years after application. These records must include, but are not limited to:

- the name of the applicator;
- the name of the landowner or customer;
- an adequate and precise description of the land area involved in an outdoor treatment and the exact address or location of any building(s) treated;
- the date and time of application;
- the pesticide product used;
- the quantity of pesticide used and the rate of application;
- the direction and estimated velocity of the wind at the time of application to any outdoor area.

In addition to meeting the State of Iowa requirements of keeping application records for three years, keeping records of pesticide use is a wise precaution. Records can establish proof of proper use in damage suits, and can also provide information to trace residue or damage problems resulting in liability cases.

Records can also help pesticide applicators save money. They allow applicators to compare the results obtained from different pesticides. Applicators can improve their pest control practices and efficiency, too. Records help to reduce pesticide misuse. Careful records from year to year help guide applicators in buying only the amount of pesticides they will need. In this way, applicators can reduce winter carryover.

The more information on record, the more useful the records will be. Applicators should carry a notebook with them in the field. All the information is right there with them, and they need not try to memorize all the necessary items. They should fill in the recommended form to be sure they get all the necessary data every time. On page 103 is a suggested spray record sheet for pesticide applicators.

Reciprocity Between States. Individuals from surrounding states should contact the Iowa Department of Agriculture and Land Stewardship to determine if certification obtained in their home state is applicable in Iowa. Each request for certification based on reciprocity is considered on an individual basis.

How to Obtain an Iowa Pesticide Applicator Company License

Companies engaged in the business of applying pesticides to the lands or properties of another must be licensed by the Iowa Department of Agriculture and Land Stewardship. Any company who employs noncommercial applicators must also be licensed by the Iowa Department of Agriculture and Land Stewardship. A company may be a person who is the sole owner and operator.

New Applicants

New applicants (companies) are to request pesticide applicator license forms from the Pesticide Section of the Iowa Department of Agriculture and Land Stewardship, Wallace State Office

Building, 900 East Grand Avenue, Des Moines, Iowa 50319, 515/281-8591.

Each commercial pesticide applicator must be listed on the license form. An owner-operator must list himself or herself. Other companies should list each individual employed by the company who is responsible for applying pesticides. In addition, indicate the categories of application in which each individual is certified.

The Iowa Pesticide Act requires that all persons applying pesticides for a company take and pass a written examination before the secretary of agriculture issues a pesticide company license.

License Renewal

Application to renew a pesticide applicator license will automatically be sent prior to each January to each pesticide company licensed the previous calendar year. This is handled by computer and will be sent like an annual billing.

License Fee

Whether using the new form or the renewal form to apply for a pesticide applicator license, attach a check made out to the Iowa Department of Agriculture in the amount of $25 to cover the annual pesticide applicator license fee.

Noncommercial applicators are exempt from payment of the annual license fee.

Proof of Financial Responsibility

In addition to buying an annual license, an applicant for a pesticide company license must file with the Iowa Department of Agriculture and Land Stewardship proof of financial responsibility either in the form of a certificate of liability insurance or a surety bond. The minimum amount of liability coverage acceptable is $50,000 each for property damage and public liability insurance, including loss for damage arising out of the actual use of any pesticide. The proof of financial responsibility may be submitted with the applicator's license or requested from the insuring or bonding company who in turn would supply the Department of Agriculture and Land Stewardship with a certificate of insurance or surety bond.

Pesticide Company Licenses for Nonresidents

Any nonresident company applying for a pesticide applicator's license in Iowa shall file a written power-of-attorney designating the secretary of state as the agent of the nonresident upon whom service of process may be made in the case of any suit against the nonresident applicator.

The written power-of-attorney must be filed with the Iowa secretary of state before issuance of the pesticide application license to the nonresident.

Other Requirements of the Iowa Pesticide Act

1. Licensing of Pesticide Dealers and Record Keeping. Pesticide dealers are individuals who distribute any amount of restricted use pesticides and are individuals whose gross annual sales of general use pesticides exceed $10,000 for each business location owned or operated by the dealer. This requirement applies to distributors of all types of pesticides, including those for agricultural or lawn and garden use. Pesticide dealers must register with the Iowa Department of Agriculture and Land Stewardship. Each pesticide dealer shall pay a minimum annual license fee of $25 or a fee based on one-tenth of one percent of the gross retail sales of all pesticides sold by the dealer in the previous year. Each pesticide dealer must file an

annual report with the secretary of agriculture listing the amount and type of all pesticides sold or applied in Iowa during each month of the previous year. The pesticide dealer must also keep a record of every sale of restricted use pesticide. Records should include: (a) the kind and amount of pesticide sold; (b) the name and address of the purchaser; (c) the purchaser's certification number; (d) the date of the sale.

While there is no specific record keeping procedure, the most acceptable method is to list on the invoice for restricted pesticides the certification number of the applicators who purchased the product.

2. Registration of Pesticides. Every pesticide that is offered for sale in Iowa must be registered with the Iowa Department of Agriculture and Land Stewardship. The annual registration fee is one/fifth of one percent of gross sales within Iowa with a minimum fee of $250 and a maximum fee of $3,000 for each and every brand and grade offered for sale. The secretary of agriculture can approve exemptions to the minimum fee.

In general, only those pesticides having a U.S. EPA registration will be registered by the state of Iowa.

Other State Regulations

Iowa Bee Rule

In June 1980, the Bee Rule took effect in Iowa. Honey bees are beneficial insects and an important aspect of Iowa's agriculture. The ruling established cooperation between pesticide applicators and beekeepers to prevent unnecessary bee kills.

Pesticide applicators must contact the County ASCS (Agricultural Stabilization and Conservation Service) to obtain all apiary locations within a two mile radius of the field being sprayed. The applicator will be given the names and addresses of beekeepers who have registered hives in the area.

The beekeepers must be notified by the applicator not less than 24 hours and not more than 72 hours prior to the time of an application of pesticides toxic to bees. If the beekeeper cannot be reached, call the State Apiarist 515/281-5736.

The Iowa "Right-to-Know" Act

The Iowa "Right-to-Know" Act became effective during 1986. Farmers are exempt from all aspects of the Iowa law. The Iowa "Right-to-Know Act provided for the following:

1. Written Hazardous Chemicals Communication Program. Employers must establish a written, comprehensive hazard communication program which includes provisions for container labeling, material safety data sheets, and employee information and training program.

2. Community Right-to-Know. Employers, upon request, have the duty to inform the public of the presence of hazardous chemicals in the community and the potential health and environmental hazards that chemicals pose.

3. Public Safety/Emergency Response Right-to-Know. Employers are required to inform local fire departments of any potentially hazardous chemicals stored within their facilities. Employers are also required to provide fire departments with Material Safety Data Sheets and the location of the chemicals stored in their facilities.

Additional information on the Iowa "Right-to-Know" Act can be obtained from the Iowa Bureau of Labor, 307 East 7th Street, Des Moines, Iowa 50319, 515/281-3606.

In addition to the Iowa Act, commercial pesticide applicators, pesticide dealers, and farmers are all affected by the Federal Emergency Planning and Community Right-to-Know Act of 1986. The act is intended to encourage and support emergency planning efforts by state and local governments with information concerning potential chemical hazards present in their communities. The Federal "Right-to-Know" Act provided:

1. Establishment of a state emergency response commission responsible for establishing emergency planning districts and local emergency planning committees. State and local emergency planning committees are responsible for completing emergency plans based on information received from local facilities storing "threshold planning quantities" (TPQ) of extremely hazardous substances. Additional information can be obtained from: State Emergency Response Commission, Room 829 Hoover Bldg., Des Moines, Iowa 50319, 515/281-6175 or 515/281-6052.

2. Any facility where an extremely hazardous substance is present in amount over the threshold planning quantity (TPQ) for more than 60 days is required to notify the State Emergency Response Commission. Notification is a written statement giving the facility's address and name of the contact person at that facility. A written listing of hazardous materials is not required.

   A facility is defined as any business where chemicals are manufactured or stored. This definition includes farming operations and small businesses. Facilities that have hazardous materials on hand above the TPQ, but for a period of less than 60 days are not required to report.

3. In evaluating whether to notify for specific products, individuals should remember that TPQ's are based on active ingredient weight not total product weight. For example, if the TPQ for a given chemical on the list is 100 pounds and that chemical makes up 20 percent of the product, notification would be necessary if 500 pounds of that product is stored at the facility.
   Two TPQ's are listed for some chemicals; carbofuran has a TPQ listing of 10/10,000. The lower threshold of 10 pounds applies to any carbofuran in liquid formulations or powder formulation with diameters less than 100 microns (.0039 inches). The upper threshold of 10,000 pounds applies to powders or granular formulation with diameters of greater than 100 microns.

4. 405 chemicals are presently included in the extremely hazardous substance list. See Table 4 in the appendix for a listing of the commonly used agrichemicals included.

On-site Containment of Pesticides Rules - Effective November 1988

These rules require that nonmobile bulk pesticide containers be located within a watertight containment facility, and any mixing or transfer of pesticides at a permanent storage and mixing site should be done within a containment area. In addition, all washing of pesticide handling and application equipment must be performed at the containment site. No pesticide rinsates or wash waters may be disposed of through storm sewers. A permanent site is one where pesticides are stored for more than 30 days per year and where more than 300 gallons and/or 300 pounds of dry

pesticide concentrate is being mixed, repackaged or transferred from one container to another. The designed site should be paved with asphalt or concrete and be elevated above the surrounding area or curbed so as not to receive runoff from surrounding areas that would overload the recovery system. In addition, the site must slope to a discharge point that allows materials to flow to a water-tight containment structure to prevent contamination from surrounding area runoff.

All containment construction plans must be submitted to the Iowa Department of Agriculture and Land Stewardship and must be signed by a registered engineer. Upon completion of construction, the Department of Agriculture and Land Stewardship must be notified in writing.

Additional information on pesticide containment may be obtained from the Iowa Department of Agriculture and Land Stewardship, Pesticide Section, Wallace Building, Des Moines, Iowa, 50319.

Iowa Chemical Spill Results in EPA Fine

The EPA sued an Iowan couple for $234,577 due to a chemical spill in a nearby river. The suit alleges that a fire at the couple's agricultural chemical store resulted in large amounts of pesticides being washed into the river. The chemicals reportedly killed more than 91,000 fish and contaminated a sewage treatment plant.

State Agencies

Iowa State University Cooperative Extension Service

The Cooperative Extension Service is responsible for providing educational training materials and training programs for individuals wishing to obtain initial certification or recertification as pesticide applicators.

Iowa Department of Agriculture and Land Stewardship

This department is responsible forcarrying out FIFRA and the Iowa Pesticide Act. The department administers the certification exams, collects the fees, issues the certification cards, and enforces the regulations.

Iowa Department of Natural Resources

This department was established in 1986 when the 74th General Assembly, merged the Department of Water, Air, and Waste Management, the Iowa Conservation Commission, the Iowa Energy Policy Council, and the Iowa Geological Survey. The central office of the Department of Natural Resources is in Des Moines, and the six field offices are located in Manchester, Mason City, Spencer, Atlantic, Des Moines, and Washington, Iowa.

This department's responsibilities include:

- monitoring the quality of groundwater and surface water,
- authorizing and inspecting water supply facilities and wastewater treatment plants,
- monitoring air quality, establishing standards, and controlling the emission of air pollutants,
- establishing and enforcing waste dumping regulations,
- regulating the construction and operation of sanitary landfills,
- responding to spills of chemicals.

Information on pesticide disposal may be obtained by calling 515/281-8693. Spills must be reported within six hours by calling a 24-hour number 515/281-8694.

Iowa Department of Health

The department is responsible for coordinating poison information centers and for collecting and maintaining reports of pesticide poisonings, methemoglobinemia, and pesticide and fertilizer hypersensitivity.

Pesticide Application Record

Certified Applicator _____ Certification Number _____ Phone _____

Customer _____ Address _____ Phone _____

Crop or other area treated _____

Number of acres or other units treated _____

Pest(s) controlled and developmental state _____

Severity of infestation, infection, etc. _____

Stage of crop growth (if applicable) _____

Date and time pesticide was applied _____

Soil condition (if applicable) _____
(wet, dry, cloddy)

Temperature _____ Humidity _____ Cloud Cover _____ Wind direction & speed _____

Pesticide used _____
(name of product and formulation)

How pesticide mixed (if applicable) _____
(active ingredient per gal, etc.)

Total amount of pesticide applied _____
(gals/lb per acre or other unit treated)

Specific location of application (if applicable): Tsp _____ Sect _____ 1/4 Sect _____

Map of treated area (if applicable)

LIABILITY

Almost all pesticides are considered hazardous. Even the most careful applicators sometimes have claims for damages against them.

COMMON CLAIMS

The usual claims are for non-performance or for injury to crops being treated or to crops in nearby fields. It is important for all applicators to be aware of the most common claims made against them.

DRIFT

Drifting pesticides are a major cause of environmental contamination and damage to nontarget areas. In general the courts have held the applicator and the grower who hired the applicator jointly liable in drift cases. The grower is responsible when hiring or contracting for a "particularly dangerous operation" such as the application of pesticide. However, the grower may file another suit against the applicator, claiming that the applicator agreed not to cause drift damage. The manufacturer of the pesticide may sometimes be held liable in drift cases. If the label does not clearly warn about the possibility of drift, the manufacturer may share liability.

CROP INJURY

Claims of injury to a crop that was treated, or claims that the pesticide had not performed as expected involve the dealer, the manufacturer, and the applicator. The courts must decide which of the three recommended or guaranteed the product for that specific use on the crop. The party in error must accept the blame and pay damages. Applicators must make sure that all the pesticides they use are recommended on the label for that purpose. If the crop injury was not great or total, the grower must show how much damage resulted from the pesticide and how much resulted from other conditions such as weather and diseases. This breakdown is not necessary in cases with great or total injury.

PERSONAL INJURY

The application of pesticides is considered especially dangerous or, in legal terms, an "ultrahazardous" activity. As a result, the pesticide applicator is liable for any injury to a person from the pesticide. Usually the injured person can recover damages without proving negligence of the applicator. The injured party must only prove that he or she is free of any negligence and did not assume the risk of pesticide exposure. Claims filed against pest control operators or exterminators differ. The liability in most cases involving personal injury or death depends on proving the applicator negligent.

WRONG FIELD

If the pesticide is applied on a field, crop or area other than the one it was intended for, serious problems can result. In the event of damage or illegal residues, or if the owner simply did not want the area treated, the applicator may be charged with trespass. Defense is very difficult. Double check on addresses, field locations, and all landmarks before you treat an area. Applying pesticides to the wrong site can be costly.

BEE INJURY

Honeybees are very important to the farmer, who often keeps colonies or hives. Unfortunately, bees are susceptible to many pesticides. If the bees in hives are killed as the result of drift, the applicator usually is held legally responsible

and often must pay damages. However, if the bees contacted the pesticides while in the sprayed fields, the applicator usually is not liable. The courts have ruled that the bee is trespassing; and that the land does not need to be safe to uninvited animals. Know where the beehives are located in your area and give the beekeeper notice beforehand of when, where, and what you will be spraying.

Attractive Nuisance

The rulings on "attractive nuisance" usually involve cases where children are attracted to ground equipment or aircraft and injure themselves. The owner and/or applicator may be held liable for leaving the "nuisance" where a child could be attracted to it. Therefore, be cautious. Do not leave ground equipment with exposed drive belts, drive wheels, gears or any moving parts alone in areas where children can get at them. Aircraft should never be parked where children can find them. Empty containers and aerosol cans are also attractive and dangerous to children. Store or dispose of them properly.

Noise

Recently, claims have been brought against applicators for noise damage. Owners of mink, poultry, turkey, and cattle ranches claim injury to their animals from fright caused by noise of aircraft and ground equipment operating above or near their ranch. They must prove direct loss of property resulting from noise from machinery operated carelessly or negligently. In some cases a ranch owner has claimed that an applicator made an unlawful flight over the property without permission. Successful defense is possible when the applicator can show that the noise was not the cause of injury or that no injury occurred.

Cross Contamination

Every year there are cases where an application actually contains not only the pesticide named on the label but another pesticide also. The materials in the tank may damage the crops being treated. There are three main ways this generally can occur.

1. The manufacturer may make a mistake in labeling or formulating the product.

2. The applicator may err in mixing or filling the spray tank, or the tank may not be empty of all the pesticide left over from the last application.

3. Open containers of some herbicides can vaporize (become a gas) and penetrate containers of other pesticides stored nearby. When the other pesticide is applied, the herbicide contamination can seriously injure the crops. The applicator must know which container of pesticide was used on the crops so that laboratory tests can be made. The lab tests can show whether the contamination occurred during mixing and filling or before. In cases involving herbicide contamination, it is difficult to prove whether it is the result of vaporization during storage or manufacturer formulation error. The courts decide who is to blame.

   (Note: All applicators should write on the label of each pesticide container the location and the date it was applied. They should also record the lot number in their records in case of cross-contamination.)

Plan of Action

If you become involved in any legal problem, act carefully and promptly. Be friendly and helpful without admitting blame. Offer to look into the matter at once.

* Examine your records to make sure that you were actually operating in the area at the time of the alleged injury.

* Make sure that all of your records are up-to-date, particularly concerning the equipment used, temperatures, wind direction and velocity, and all pertinent data.

* Proceed to the scene immediately and make notes of all essential information.

* If applicable, have proper samples taken. Contact the Pesticide Division of the Iowa Department of Agriculture and Land Stewardship. Improperly collected samples are useless in court.

* Record the presence of any adverse condition that you observed at the time of your investigation, particularly insect infestations, disease, water stress, late planting, carry over effect from other materials or herbicides, and stage of the crop.

* Photograph any adverse condition found with color film at a sufficiently close focal length so that the symptoms can be examined by an expert.

* Save the container from the product used in the job. If it is not practical to save the whole container, use closeup color photography to record the label.

* Notify your insurance company immediately.

* If you do not have insurance for the loss involved, request permission to have an expert examine the crop or the property, in order that you may have the benefit of his or her opinion.

* If a chemical company is involved notify a representative immediately. They will probably want to send their experts to the site, too.

* Obtain the names and addresses of all witnesses who might testify concerning the nature of the operation and conditions of the crop or site before and after the application. In the event that the crop is perennial, examine the USDA aerial photographs to determine the condition of the planting in years prior to the year of alleged injury.

INSURANCE

To protect yourself and your business, you should have insurance for possible pesticide mishaps. There are many different types of insurance plans ranging from bodily injury, property damage, and restricted chemical liability to comprehensive chemical liability. The plan you choose should fit your needs and your business. If you are in a relatively low risk position from a legal standpoint (such as a golf course superintendent) then minimum coverage may be enough. On the other hand, aerial applicators will probably need more insurance. Be sure to explore the costs, benefits and drawbacks of insurance before you buy. You need to know exactly what you are covered for. An insurance agent who specializes in pesticide insurance is the best person to advise you on your individual insurance needs.

Table 3. Pesticides included on the RCRA Hazardous Waste Listing

Common Name	Trade Name(s)
*Aldicarb	Temik
*Aldrin	Aldrite
Amitrole	Amizol
*Arsenic Pentoxide	
*Arsenic Trioxide	
Cacodylic Acid	Phytar
Carbamic acid	
Chlordane	
*Copper Cyanides	
1,2-Dibromo 3-Chloropropane	DBCP, Nemafume, Nemanox
1,2 and 1,3 Dichloropropene	Telone II Soil Fumigant
2,4-D	
DDT	
*Dieldrin	
Dimethoate	Cygon, De-Fend
Dimethylcarbamoyl Chloride	
*Dinitrocresol	DNC, Chemsect, Detal, Nitrador
*Dinoseb	Premerge
Disodium Monomethanearsenate	DSMA
*Disulfoton	Di-Syston
*Endosulfan	Thiodan
*Endrin	
Ethylmercuric Chloride	
*Famphur	Famfos, Warbex
*Heptachlor	
Hexachlorobenzene	HBC
Kepone	Chlordecone
Lindane	Isotox Seed Treatment
2-Methoxy Mercuric Chloride	MEMC
Methoxychlor	Marlate
*Methyl Parathion	Penncap-M
Monosodium Methanearsenate	MSMA
*Nicotine	Black Leaf 40
*Parathion	Ethyl Parathion, Niran
Pentachloronitrobenzene	PCNB
*Pentachlorophenol	Penta, PCP
Phenylmercuric Acetate	PMA
*Phorate	Thimet
*Strychnine	
*2,4,5-T	Weedar, Weedone
*2,4,5-TP	Silvex
*Thallium Sulfate	
Thiram	
*Toxaphene	
Warfarin	

[1] Pesticides marked with an asterisk are designated acutely hazardous. This listing may not be inclusive, check pesticide labels for further information on hazardous waste disposal.

Table 4. Pesticides subject to Right-to-Know Legislation

Chemical Name	Trade Name	Threshold Planning Quantity (Pounds)
Aldicarb	Temik	100/10,000
Aluminum Phosphide	Phostoxin	500
Azinphos-Ethyl	Ethyl Guthion	100/10,000
Azinphos-Methyl	Guthion	10/10,000
Carbofuran	Furadan	10/10,000
Chlordane	Belt	1,000
Chlorfenvinfos	Supona, Birlane (discontinued)	500
Coumaphos	Co-Ral	100/10,000
Cycloheximide	Acti-Aid - growth reg	100/10,000
Demeton	Systox	500
Dichlorvos	DDVP, Vapona	1,000
Dimethoate	Cygon, DeFend	500/10,000
Dinoseb	Preemerge, Dynap, Klean Krop	100/10,000
Disulfoton	Di-Syston	500
Endosulfan	Thiodan, Tiovel	10/10,000
Endrin		500/10,000
EPN	EPN	100/10,000
Ethion	Nialate	1,000
Ethoprophos	Mocap	1,000
Fenamiphos	Nemacur	10/10,000
Fensulfothion	Dasanit	500
Fonofos	Dyfonate	500
Lindane	Gamma BHC	1,000/10,000
Methamidophos	Monitor	100/10,000
Methidathion	Supracide	500/10,000
Methiocarb	Mesurol	500/10,000
Methomyl	Lannate, Nudrin	500/10,000
Methyl Bromide	Dowfume	1,000
Methyl Isothiocyanate	Vapam - soil fumigant	500
Methyl Parathion	Penncap-M	100/10,000
Mevinphos	Phosdrin	500
Mexacarbate	Zectran (discontinued)	500/10,000
Monocrotophos	Azodrin	10/10,000
Oxamyl	Vydate	100/10,000
Paraquat		10/10,000
Parathion	Niran	100
Phorate	Thimet	10
Phosfolan	Cyolane	100/10,000
Phosmet	Imidan, Prolate	10/10,000
Phosphamidon	Dimecron	100
Pirimifos-Ethyl	Primicid	1,000
Promecarb	Carbamult	500/10,000
Strychnine		100/10,000
Terbufos	Counter	100
Warfarin Sodium	Co-Rax, Rodex	100/10,000
Zinc Phosphide	ZP Tracking Powder	500

[1]This listing may not be inclusive, check with the emergency response commission for further information.

Sample Test Questions

1. A pesticide which by law may be bought and applied only by certified applicators is called:

   a. General use pesticide
   b. Restricted use pesticide
   c. Certified pesticide
   d. Special Label pesticide

2. Drift may be caused by:

   a. Wind
   b. Small nozzle opening
   c. High pump pressure
   d. All of the above

3. The tendency of pesticides to progress through food chains and concentrate in tissues is termed:

   a. Chemical incorporation
   b. Chemical adsorption
   c. Biological degradation
   d. Biological accumulation

4. A pesticide product label recommends applying 2 quarts of a 6E formulation per acre. Your sprayer hold 42 gallons and applies 6 gallons per acre. How many quarts of 6E do you need per tank?

   a. 0.5
   b. 3.5
   c. 10.5
   d. 14.0

5. Which of the following always appears on all pesticide labels?

   a. Warning
   b. Caution
   c. Keep out of the Reach of Children
   d. Danger

6. It is important to realize that the toxicity rating for a pesticide is only approximate. Pesticides are grouped according to their LD_{50}. Which of the following groupings of LD_{50} is the most toxic?

   a. 1-50
   b. 50-500
   c. 500-5000
   d. 5000-15,000

7. What types of gloves should be worn when handling highly toxic pesticides?

   a. Leather gloves
   b. Canvas cotton gloves
   c. Unlined neoprene (rubber) gloves
   d. Cloth-lined gloves

8. Which agency is responsible for regulating and enforcing pesticide use in the state of Iowa?

   a. Department of Natural Resources
   b. ISU Cooperative Extension Service
   c. Department of Agriculture and Land Stewardship
   d. Department of Health

9. The downward movement of a pesticide in the soil is called:

   a. volatization
   b. photodecomposition
   c. leaching
   d. All of the above

10. All adult insects have which two characteristics in common?

    a. Six jointed legs and two body regions
    b. Four jointed legs and three body regions
    c. Six jointed legs and three body regions
    d. Eight jointed legs and two body regions

11. Disease symptoms on plants may be caused by:

    a. nutrient deficiency
    b. bacteria
    c. toxic chemicals
    d. all of the above

12. Plants which grow from seed, mature and produce seed for the next generation in one year or less, and then die are called?

    a. simple perennials
    b. perennials
    c. biennials
    d. annuals

13. Releasing an insect's natural enemies in a target area is what type of control method?

    a. Legal control
    b. Cultural control
    c. Biological control
    d. Mechanical control

14. Your sprayer is delivering 5 gallons per acre working at 20 pounds of pressure. You wish to double the rate of discharge by increasing your pressure. What pressure should you use to recalibrate your sprayer?

    a. 60 psi
    b. 40 psi
    c. 80 psi
    d. 15 psi

15. Danger is the signal word on the pesticide label if the lethal dose for a 150 lb. person is:

    a. Few drops to 1 teaspoon
    b. 1 teaspoon to 1 ounce
    c. 1 ounce to 1 pint
    d. More than 1 pint

Question	Answer
1	b
2	d
3	d
4	d
5	c
6	a
7	c
8	c
9	c
10	c
11	d
12	d
13	c
14	c
15	a

Before Using Any Pesticide

STOP

Read The Label

All pesticides can be harmful to health and environment if misused. Read the label carefully and use only as directed.