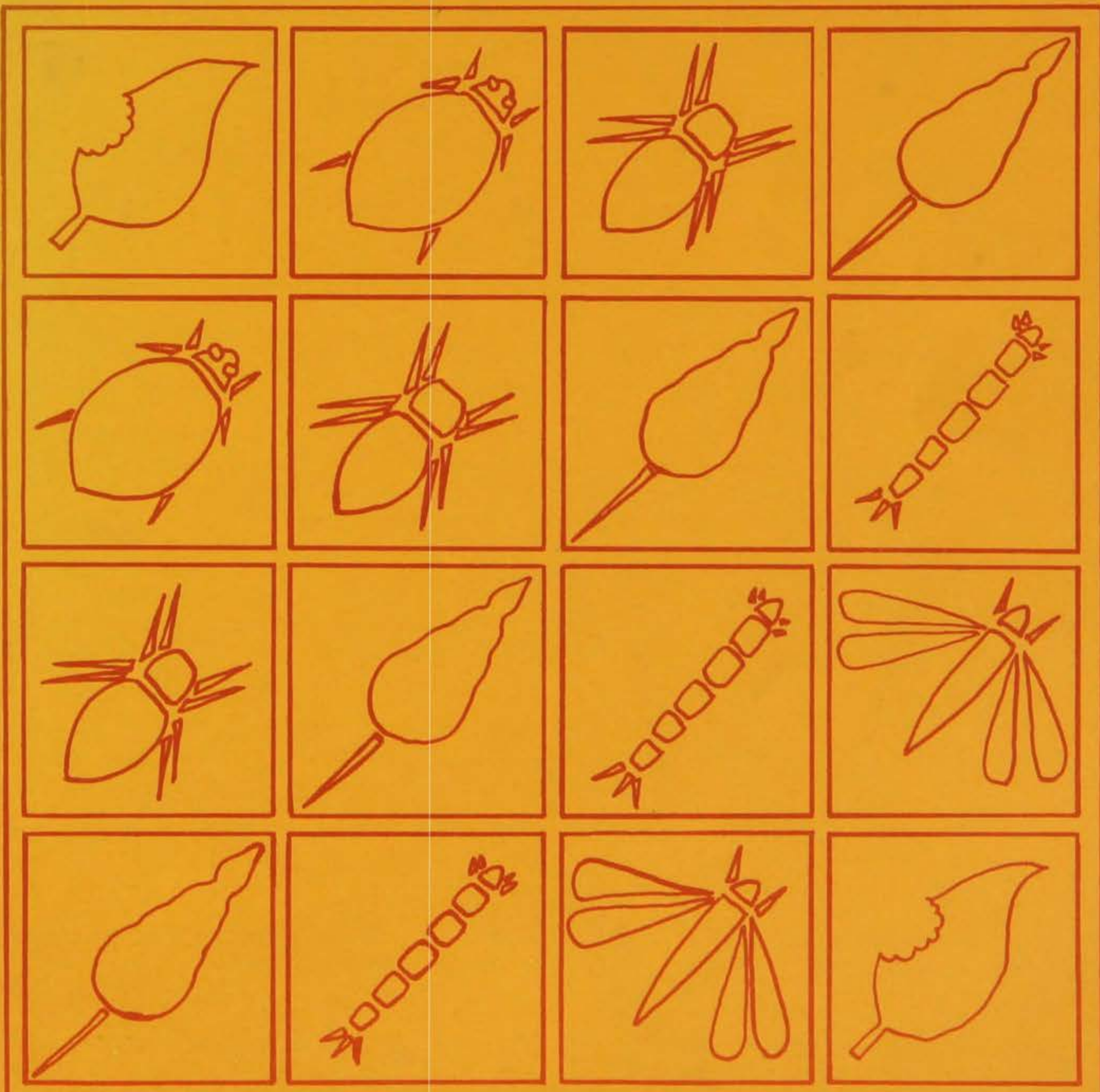
MINNESOTA EXTENSION SERVICE
UNIVERSITY OF MINESOTA

Private Pesticide Applicator's Training Manual

Prepared by extension specialists at the University of Minnesota



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INTRODUCTION

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

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

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

1. Recognize the common pests (weeds, plant diseases, insects, rodents) in your area and the damage caused by them.

2. Read and understand the labels on pesticide containers.

3. Apply pesticides in accordance with label directions and warnings.

4. Recognize environmental situations that must be considered during application to avoid contamination.

5. Recognize poisoning symptoms and procedures to follow in case of a pesticide accident.

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

WHAT IS A PEST?

An "agricultural pest" may be defined as any living organism which competes with man for food or fiber. Agricultural pests include weeds, insects, arachnids (mites and ticks), fungi, bacteria, nematodes, viruses, birds, mammals, and parasitic plants. A complete list would also include other parasites of livestock and plant disease agents of lesser importance.

The designation of a particular organism as a pest depends on both the "habits of the organism" and "their relation to man". For example, an insect which attacks a plant or an animal which is not useful to man would not be considered a pest, even though the particular plant or animal might not agree.

PESTS IN HISTORY

Agricultural pests have played an important and frequently critical role in man's history. In ancient times, the devastation they caused was often the object of intense fear and superstition, even to the point of assuming a central role in a particular culture. It is only in recent times that man's response has been based on any appreciable understanding of the nature and causes of pest problems.

One of the early references to an agricultural pest is an inscription on a tablet found by archaeologists in the Mideast and dating to about 1900 BC. The inscription describes the "dread samana disease" of barley; the disease may indeed have been stem rust which we know was devastating in the Mediterranean area in later Greek and Roman times. The Romans, in fact, held an annual festival in honor of the "rust god", Robigo, during which dogs and sheep were sacrificed in the hope of obtaining the favor of the god and protection from the disease.

Oftentimes, pest infestations were viewed as punishment inflicted by the gods. The following passages from the Old Testament serve as particularly striking examples:

> "I smote you with blight and mildew; I laid waste your gardens and vineyards; your fig trees and your olive trees the locust devoured".
>
> Amos 4:9

> ...And the Lord brought an east wind upon the land all that day, and all that night; and when it was morning, the east wind brought the locusts. And the locusts went up over all the land of Egypt, and rested in all the coasts of Egypt; very grievous were they; before then there were no such locusts as they, neither after them shall be such. For they covered the face of the whole earth, so that the land was darkened; and they did eat every herb of the land.
>
> Exodus 10:13-15

It would not be an exaggeration to say that pests have indeed altered the course of human history; they continue to do so today. A classic example is that of the Irish potato famine of the 19th century which not only played a critical role in later Irish history but also influenced significantly the course of events in England, the United States, Canada and a number of other countries.

In 1845, late blight of potato, a fungus disease, destroyed the Irish potato crop. In a country where the majority of the people worked land owned by absentee English landlords, the Irish peasantry depended almost completely on the potato for food.

> The green fields turned black almost overnight, and tubers, hastily dug, collapsed into stinking masses, and the fearful stench of decomposition hung over the land.

The food supply of the majority of Ireland's people had been destroyed. A million Irishmen starved; a million and a half more emigrated to America. Through it all, no one knew the cause of the blight.

> Where did the rot come from, people asked fearfully? Did it fall from the sky in rain, did it drop from the clouds, did it rise from the ground? Had the soil itself become infected?
>
> Wild suggestions were advanced. Had the potatoes become blighted by "static electricity", generated in the atmosphere by puffs of smoke and steam issuing from the hundreds of locomotives that had just come into use? Or was the disease caused by "moritiferous vapours" rising from "blind volcanoes" in the interior of the earth? Another school of thought blamed guano manure, consisting of the droppings of the sea fowl, which had recently become fashionable.

We've come a long way since then, but there remains much about pests and their damage that we still don't fully understand. The agricultural pest is with us as much as ever and its influence still alters the lives of men and the course of nations. It is man's understanding and response that have changed and will continue to change.

THE ECONOMICS OF PEST DAMAGE

It is exceedingly difficult to make accurate estimates of losses due to pests, and loss figures should be viewed with some reservations. There is no question, however, that these losses are of substantial and often staggering proportions.

A conservative estimate made in 1974 suggested that plant pests destroy one third of mankind's supply of food and fiber every year. Losses of much greater magnitude occur as a matter of course in many less developed countries. For example, figures from a recent study made by the National Academy of Sciences indicate that if only 20% of the present preharvest losses of rice could be eliminated, the increase in production would be nearly enough to feed the the combined populations of Japan and Bangladesh--approximately 177 million people.

In 1967, in the United States alone, it was estimated that crop pests accounted for losses of nearly $15 billion; in the same year, the total value of crops produced was only $21.4 billion. Of that nearly $15 billion loss, an estimated $5.4 billion was due to weeds, $5.1 billion to insects and mites, $3.7 billion to diseases, and $0.4 billion to nematodes. Based on earlier figures, livestock pests probably accounted for additional losses totaling $2-3 billion. And this is a country which has the full benefits of modern technology and sophisticated control techniques. There are, indeed, indications that percent crop losses in the U.S. due to pests have not been appreciably reduced in the last few decades.

PRINCIPLES OF PEST CONTROL

> "Would you tell me, please, which way I ought to go from here?" "That depends a good deal on where you want to get to."
>
> Lewis Carroll, Alice in Wonderland

Control of a particular pest should be considered only when it is believed that "economic damage" will occur. Economic damage is simply the amount of injury which will justify the cost of applied control measures; it is distinct from "biological damage" which frequently occurs without economic loss.

Once it has been determined that control measures are needed, a control program should be based on an understanding of the biology and habits of the pest, a consideration of **all** effective methods of control, and recognition of the **level** of control that is both desirable and possible.

> Before one can speak authoritatively on "pest control", the nature of a pest infestation must be defined. The harsh reality of the situation is that we must live with pests--be they insects, mites, snails, worms, fungi, bacteria, viruses, epiphytic plants...or weeds. Rarely do we eradicate them; the best we can do is to coexist with them.

The primary goal of a pest control program is a reduction of pest **damage** to an acceptable level. In most cases, our objective need not be, and indeed should not be, total eradication of the pest in question. Eradication is usually an unrealistic goal and our efforts may, in the end, create more problems than they solve--e.g. pest resistance, secondary pest outbreaks, resurgence, environmental contamination.

THE DECISION-MAKING PROCESS

An orderly process of decision-making must be followed in order to intelligently and effectively plan and carry out a pest control program. The principal elements of that process are outlined below; although we will deal specifically with crop pests, the general principles are also applicable to pests of livestock.

DETECTION

The importance of detecting pest infestations **before** they become a problem cannot be overemphasized. Failure to do so will often result in increased costs of control, less effective or ineffective control measures, and significant damage to the crop.

Proper detection requires frequent and careful field-checking, a knowledge of the common pests of the particular crop in question, an ability to recognize potential problems, and a thorough knowledge of the growth characteristics of the crop--an ability to recognize "abnormal" plants and pest damage is a must. If you see something unfamiliar or something which "doesn't look right", contact your county extension office or another source of **reliable** information.

IDENTIFICATION

Positive identification of an organism is essential in order to determine whether it is a pest and, if so, to establish the necessity and elements of a control program. In the case of plant diseases, identification can sometimes be based on symptoms rather than actual identification of the disease agent. You should be familiar with the common pests of the crops you grow; if you have any doubts, contact your county Extension office for positive identification.

BIOLOGY AND HABITS

Identification is little more than a tool. Once we have identified an organism, we then have access to available information regarding its biology and habits. It is this information which allows us to formulate effective control programs. Knowledge of an organism's life cycle and its relation to various environmental conditions is essential in determining when significant damage might occur and when control measures would be most effective and economical. It obviously makes sense to direct our control efforts against the most vulnerable stages of an organism's life cycle and to protect our crops when the likelihood of significant damage is greatest.

ECONOMIC SIGNIFICANCE

We noted earlier that control of a particular pest should be considered only when it is believed that economic damage will occur. Simply stated, nothing is to be gained if the cost of controlling the pest is greater than the damage it is causing.

It's natural for most of us to want to follow the old saying, "Better safe than sorry"! This is often not a good guide, however, when it comes to pest control. We should of course do everything we can in our normal operations to create the most favorable conditions for the crop and the least favorable conditions for potential pests. We should not, however, apply additional controls, particularly chemical controls, "automatically". We must first establish that they are really needed. Otherwise, it will be a waste of both time and money.

Determining when pest damage is economically significant is often not an easy task. A number of factors must be considered, including the pest population, geographic location, crop variety, the growth stage of the crop, the value of the crop, and the cost of control. In assessing these factors, we often speak of the economic injury level (EIL), which for our purposes will be defined as the population density at which the pest causes a reduction in the value of the crop that is greater than the cost of control. It is important, therefore, that control measures be applied before the economic injury level is reached--that is, before damage exceeds the cost of control. The level at which control measures should be applied is referred to as the economic threshold level (ETL). The ETL is defined as the population density at which control measures should be instituted to prevent an increasing pest population from reaching the economic injury level. The ETL, which is also referred to as the "treatment threshold" or the "action threshold", is not the level at which damage first becomes apparent, although the two may coincide. Economic thresholds have been established for a number of crop/pest systems, particularly those involving insect pests. A substantial amount of information is required in determining threshold levels, however, and much additional research needs to be done before reliable figures are available for other systems.

In any consideration of pest damage, environmental conditions are important but largely unpredictable variables which affect pest activity and population levels and crop succeptibility. Environmental factors are particularly important as they relate to the development of plant diseases. Although unpredictable, these factors must be taken into account in making pest control decisions.

> It is clear...that it is extremely difficult to forecast how much loss of yield a given infestation is likely to cause, especially when it is realized that many factors will influence the population density of the pest later. Yet this is what the farmer must do if he is to make a rational decision...

SELECTION OF METHODS

Once a pest problem has been identified, the biology and the habits of the pest understood, and the economic significance established, the appropriate method or combination of methods can be selected in order to achieve **effective, practical, economical**, and **environmentally sound** control. The last of these criteria is no less important than the first three. Proper selection requires that you be thoroughly familiar with **all** available control methods and that you fully evaluate the benefits and risks of each.

Bear in mind that a comprehensive pest control program requires planning and preparation. It is perhaps least effective when control measures are applied solely as immediate responses to problems that arise during the growing season. At that point, direct action is usually necessary and the use of pesticides is often the only alternative.

EVALUATION

It is extremely important to evaluate the results of your control program. This can be done in several ways such as counts of pests or infections before and after treatment, comparative damage ratings, yield data, etc. In most cases, it is difficult, if not impossible, to do an adequate evaluation without leaving untreated checks to use as a basis for comparison. The results obtained should be recorded for future reference.

In our efforts to control pests, how often do we simply use the handiest or cheapest pesticide? How often do we forget to consider other methods or combinations of methods? How often do we forget about the effects on the environment? It may be too often. An intelligent and informed selection of the most appropriate pest control method or methods is an absolute necessity in modern agriculture.

We will not attempt in this section to discuss in depth the vaious methods of pest control. They will be dealt with more fully in later sections. Our intent here is simply to give you an overview of the alternatives available and to present some characteristics and examples of each.

RESISTANT VARIETIES Frequently, pest problems can be avoided or minimized simply by planting resistant varieties. The degree of resistance to a particular pest may be either partial or complete.

Resistant varieties possess genetic defenses such as protective physiological or physical characteristics which reduce their susceptibility to pests. In corn, for example, varieties with thicker husks are better protected from the corn earworm and varieties with greater root system regrowth capabilities can better withstand corn rootworm attack. New varieties of pest-resistant plants are continually being developed in order to keep pace with constantly changing pests. Whenever possible, you should consider using resistant varieties; avoiding a pest infestation is usually easier and less expensive than managing one that has already become established.

CROP ROTATION Crop rotation can be an effective means of maintaining pest populations at manageable levels; often times it is a necessity. If a crop which is susceptible to a particular pest is grown year after year on the same land, pest infestations can become devastating. Rotation to other crops may offer at least a partial solution and may at the same time provide additional benefits such as increased soil fertility and a reduction in soil erosion.

CULTURAL CONTROL Cultural control includes a number of practices designed to create optimal growing conditions for the crop and/or unfavorable conditions for the pest. Many involve normal farming operations such as planting, cultivating, fertilizing, irrigating and harvesting which may be altered somewhat in response to particular pest problems. Others are more specifically designed for pest control; an example might be the planting of "trap crops"--expendable crops which are more attractive to the pests than the crops being grown. Sanitation practices, such as removal of crop residues which harbor pests, can also be effective means of cultural control. Many pest problems can be avoided or minimized by using appropriate cultural control techniques. Don't overlook them.

BIOLOGICAL CONTROL The fundamental form of biological control focuses on maximizing the effects of the "natural enemies" of pests. There are perhaps thousands of naturally-occurring species of insects, mites, nematodes and disease agents which are predators and parasites of the pests of agricultural crops. You should see to it that these natural enemies are preserved in your fields--it will be to your benefit. This requires a careful choice of pest control measures, particularly an informed selection and judicious use of pesticides. You can also help to ensure the

continued presence of these species by preserving appropriate habitats in surrounding vegetation.

Predators and parasites may also be intentionally introduced, particularly from foreign countries, for the control of specific pests. There are now nearly 100 species of imported parasites being used for pest control in the U.S.

MECHANICAL AND PHYSICAL CONTROL

Although of generally lesser importance, mechanical and physical methods may be used with some effectiveness against certain pests. Some examples are:

- Traps for rats, mice, and birds.
- Light to attract or repel pests.
- Sound to kill, attract, or repel pests.
- Radiation to sterilize or kill pests
- Cold or heat to kill pests

CHEMICAL CONTROL

Despite their potential hazards, chemicals are essential components of pest control programs and will remain so for the forseeable future, They act quickly and are effective against large pest populations. In many cases, the application of pesticides may be the most effective and feasible control tactic.

Pesticides and their use are the principal concerns of this manual. We will not, therefore, discuss them any further at this point except to emphasize that they should be used only when needed and in such a manner that you, your neighbor, and the environment are adequately protected.

There are a number of other specific pest control methods which might be discussed. Some are of relatively minor importance in Minnesota. Others are newer techniques, many of which are stil in developmental stage and may prove to be of significance in pest control programs in the coming years; a number of these will be discussed in later sections.

INTEGRATED PEST MANAGEMENT

Recognition of the problems associated with widespread pesticide use has encouraged the development and utilization of alternative pest control techniques. Attention is being directed to the coordinated use of multiple tactics, an approach known as "integrated pest management (IPM)". IPM is an interdisciplinary approach incorporating the judicious application of the most efficient methods of reducing pest damage to acceptable levels.

IPM is by no means a new concept; some forms of integrated pest control have been practiced for centuries. The significance of today's IPM concept is that it is based on a scientific and systematic approach. Development and implementation of an IPM program requires an understanding of both the crop and the pest and a thorough familiarity with available control tactics. Again, IPM is not a new concept and the principles of pest control we have discussed thus far are, in effect, principles of integrated pest management.

IPM has come to mean different things to different people. For that reason, it is unlikely that any one definition will satisfy everyone. For the purposes of this discussion, we will consider as:

> An **ecological** approach to pest management in which **all available necessary techniques** are consolidated into a **unified program** so that pest populations can be **managed** in such a manner that **economic damage is avoided** and **adverse side effects are minimized.**

The principal features of the definition are emphasized. It is an **ecological** approach, an approach based on a thorough understanding of both the crop and the pest and their interactions with each other and the environment. Such understanding requires a significant amount of reliable information; a great deal of research is now being conducted throughout the country to establish this data base.

IPM is an approach which uses **all available techniques.** Informed consideration is given to all methods of pest control when formulating a control program. This includes both nonchemical and chemical methods. These control tactics are, however, applied only when they are **necessary**; an important element of an IPM program is determining when controls are, in fact, necessary. It requires that fields be checked carefully on a regular basis. To that end, many programs employ "scouts" whose principal function is to monitor pest populations.

IPM is a **unified program** which integrates all beneficial control measures into a comprehensive pest control program which is intelligently planned and executed.

Pest populations are, by definition, **managed** in an IPM program. They are not eradicated, they are not "gotten rid of"--they are instead maintained at acceptable levels at which **economic damage is avoided.** This concept, which is a highly realistic and sensible one, has definite implications for the degree of pest control we attempt to exercise. If "total annihilation" of pest populations is both unnecessary and unrealistic, perhaps the extent of our control, particularly the amount of pesticides we use, need not be as great.

Finally, in IPM programs **adverse effects** which might result from pest control measures **are minimized.** Adverse effects can range from destruction of the natural enemies of pests and the killing of other beneficial species, such as honeybees, do harm to ourselves, our neighbors, and the environment. They most often result from the overuse or improper use of pesticides. It is important to note that adverse side effects are minimized, not eliminated. We must do everything within reason to reduce them to the lowest possible level, but to eliminate them entirely is certainly not practical and is probably not possible. We do not live in a "zero-risk" world; the best that we can do is to assess the benefits and risks of each of our endeavors with as much wisdom as we can muster and make our decisions accordingly.

Now that we have indicated what we believe integrated pest management is, let us say a few words about what it is not. It is, first of all, not a "cure-all" for all our pest and environmental problems simply because, at present, no pest control program can be. Secondly, it is not, as such, as anti-pesticide concept. Pesticides are an integral part of most IPM programs. IPM simply asks that we formulate our pest control programs using all available techniques and not rely solely on a single-method approach. And it asks that we apply pesticides only when necessary. Careful monitoring of pest populations and environmental conditions are ways we can determine when pesticides are really needed. The result will be a more judicious, economical, and effective use of pesticides.

Frequently, implementation of an IPM program leads to a decreased use of pesticides, although in some instances careful monitoring has in fact shown the need for more frequent applications. The U.S. Department of Agriculture has predicted a reduction in pesticide use during the 1980's in part due to the increasing use of IPM.

PESTICIDE APPLICATOR LAWS AND REGULATIONS

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

FEDERAL LAWS, REGULATIONS, AND AGENCIES

The Federal Insecticide, Fungicide, and Rodenticide Act (FIFRA) requires you to show that you know the correct way to use and handle pesticides.

Here are the parts of the law which concern you the most:

- It says that all pesticide uses must be classified as either general or restricted.
- It requires you to be certified as competent to use any of the pesticides classified for restricted use.
- It provides penalties (fines and jail terms) for people who do not obey the law.

Congress set October 21, 1976, as the date for certification to go into effect. The Environmental Protection Agency (EPA), acting under Federal law, has by regulation set minimum standards of competency for all commercial applicators. The State of Minnesota has developed a plan for certification of competency that meets national standards. The certification plan is administered by the Minnesota Department of Agriculture.

CLASSIFICATION OF PESTICIDES

Manufacturers must register every pesticide with EPA. By regulation, when each pesticide is registered, all its uses must be classified. EPA must decide whether each use is a general or restricted one.

Under law, pesticide uses that will damage the environment very little or not at all, when done as the label directs, can be classified as general use.

Uses that could cause damage even when done as directed on the label must be classified as restricted use. They may be carried out:

- by someone who is certified or
- under a certified person's supervision.

Some uses may be general under some conditions and restricted under others.

CERTIFICATION OF APPLICATORS

What is certification? It is proof that you know the safe and correct way to carry out restricted uses. Both private and commercial applicators have to meet state and national standards.

There are three categories of Pesticide Applicators in Minnesota:

1. Commercial Applicators - Persons who apply pesticides for hire.

2. Non-Commercial Applicators - Persons who apply pesticides as an employee of a company, institution or unit of government with the company, institution, or government jurisdiction (examples: a person who as an employee of a feed mill controls rodents and incests in that mill; a county employee who sprays roadsides in that county; a University of Minnesota technician who applies herbicides in a field plot).

3. Private Applicators - Persons who apply pesticides on land or in buildings which they own or rent.

USE INCONSISTENT WITH LABELING

Let us now look at why "use of a registered pesticide in a manner inconsistent with its labeling" was made illegal. The registration of a pesticide use requires submission of data to show the effects that use may have. Injury may occur on plants or animals not listed on the label and, in fact, if more pesticide is applied than what is specified on the label, injury to the target crop or animal may also occur. In addition, human exposure resulting from unlabeled uses might control pests and provide some economic security, the potential side effects on health and safety could not be evaluated. In other words, if a use was not justified by the registrant, the effect the use might have on humans or the environment could not be assessed. Rather than allow use of a pesticide in a manner which might eventually lead to unforeseen problems and result in cancellation of all uses, the policy was established to prohibit uses not specified on the label. If pesticide uses are studied and can be justified, then those uses can be added to the label. The uses of a pesticide are thereby limited to those which are based on scientific facts.

The definition of "to use any registered pesticide in a manner inconsistent with its labeling" (Sec.2(ee) of FIFRA) was modified in 1978 to allow for some deviations from the label. If, however, any problems result because of these uses, the applicator alone is liable for the consequences. There are four exceptions by which an applicator can deviate from label directions:

1. Apply a pesticide at any dosage, concentration, or frequency less than that specified on the labeling.

2. Applying a pesticide against any target pest not specified on the labeling if the application is to the crop, animal, or site specified on the labeling, unless the Administrator has required that the labeling specifically state that the pesticide may be used only for the pests specified on the labeling after the Administrator had determinted that the use of the pesticide against other pests would cause an unreasonable adverse effect on the environment.

3. Employing any method of applicaiton not prohibited by the labeling.

4. Mixing a pesticide or pesticides with a fertilizer when such mixture is not prohibited by the labeling.

The applicator is responsible for proper pesticide use.

PENALTIES

If you violate the FIFRA, you are subject to civil penalties. They can be as much as $5,000 for each offense. Before EPA or the state can fine you, you have the right to ask for a hearing in your own city or county. Violations of the law may also subject you to criminal penalties. They can be as much as $25,000 or 1 year in prison, or both.

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 tell you which pesticides:

- are dangerous to humans, and
- create a health hazard during transportation.

If you ever haul pesticides between states, you should know the following:

- 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 contact DOT right away after each accident:
  a) when someone is killed
  b) when someone is injured badly enough to go to a hospital, or
  c) when damage is more than $50,000.
- You must tell DOT about all spills during shipment.

State and local laws may require you to take additional precautions.

AERIAL APPLICATION

Application of pesticides from airplanes also is regulated by the Federal Aviation Administration (FAA) and by the state. FAA judges:

- the flying ability of pilots, and
- the safety of their aircraft.

FAA rules, too, say that an aerial applicator may not apply any pesticide except as the label directs.

WORKER SAFETY

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

The pesticide label may indicate a re-entry limit before workers may safely enter or work in a treated field.

RESIDUES

The pesticide that stays in or on raw farm products or processed foods is called a residue. EPA sets residue tolerances under regulations authorized by the Federal Food, Drug, and Cosmetic Act. A tolerance is the concentration of a pesticide that is judged safe for human use. Residues in processed foods are considered to be food additives and are regulated as such.

Tolerances are expressed 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 the product. The same pesticide may have a different tolerance on different products. It might be 50 ppm on grapes and 25 ppm on apples.

If too much residue is found on a farm or food product, the product may be seized or condemned.

The label will tell you how many days before harvest the pesticide may be applied. Follow the label exactly. Then you can be sure you are not breaking the law.

STATE LAWS AND AGENCIES

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

Minnesota Pollution Control Agency: (1) Controls and regulates the disposal of containers and excess pesticides. (2) Controls the burning of trash.

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

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

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

State Plant Pest Act. (7) Investigates pesticide misuse and pesticide accidents.

The Minnesota Department of Agriculture also performs most of the FIFRA enforcement activities within the state under an agreement with EPA.

The certification and licensing of commercial and noncommercial pesticide applicators in Minnesota is accomplished by the satisfactory completion of appropriate examinations and other requirements.

Private applicators are certified by participating in training provided by county extension offices. This training can include a county meeting or completion of a home study course provided by Agricultural Extension, Office of Special Programs. Upon completion of training the participant submits an application for certification. A temporary card **will be issued, and can be used until the participant receives the Pesticide Applicator Training Identification (P.A.T. I.D.) "card".** The P.A.T. I.D. card is valid for 5 years to the applicator's nearest birthday and is used when purchasing Restricted Use Pesticide Products. The fee covers instruction materials which include a manual, worksheets, certification application card, and self addressed return envelope.

THE PESTICIDE LABEL

THE MAKING OF A PESTICIDE LABEL	Label clearance for each pesticide that reaches the market requires detailed field and laboratory tests and a price tag of several million dollars. The facts below can help us better appreciate the effort that goes into the pesticide label and the value of the information on the label to the user.
YEARS OF SCREENING	Pesticide producing companies spend years making and screening thousands of compounds to find a pesticide. For each pesticide that reaches the market, 7,500 compounds are passed over.
YEARS OF DEVELOPMENT	As soon as a pesticide producing company believes it has discovered a useful and worthwhile product, wide scale testing and label clearance procedures are started. Each pesticide will require approximately 7 years of development before it reaches the market.
TESTS REQUIRED	Before a pesticide can be marketed toxicological, metabolism, residue, persistence, soil movement, and performance tests to determine its effect on the environment and its usefulness against target pests over a wide range and area of conditions are required.
TOXICOLOGICAL TESTS	These tests determine the possible hazards of the new pesticide to man, animal life, and the environment. The pesticide is fed by mouth and applied to the skin of test rats, rabbits, and other animals. Tests are conducted to determine if it has gases or vapors that would harm the skin or the eyes. Tests are conducted to determine if the material will cause injury or cancer when fed to animals for long periods of time, or if it will affect the offspring of these animals.
METABOLISM STUDIES	These studies are made to determine how and how long it takes the compound to break down into simple, less toxic or harmless materials.
RESIDUE TESTS	These tests determine how much of the pesticide or its breakdown products remains on the crops. With the use of accurate equipment, amounts can be found (if present) as low as one-tenth of a part per million (five drops in one thousand gallons). Similar tests determine residues (if any) in the meat of cattle, swine, and poultry, and also in milk and eggs. From this data residue tolerances are established.
SOIL MOVEMENT TESTS	Tests are performed to determine how the pesticide moves in the soil and ground water, and how long it remains in the soil where it might be absorbed by crops planted later in the same field.
WILDLIFE TESTS	Tests are performed to determine the immediate and long range effects of the field application of pesticides on wildlife. The possibilities of residue building up in wildlife are checked on mammals, fish, and bird.

PERFORMANCE TESTS

The producing company must prove that the new pesticide has practical value as a crop protection tool. Efficacy data (results on how good the pesticide is) must be collected on each pest and from each crop on which the material will be used. Tests on crop varieties, soil types, application rates and number of applications are required. The results must show that the pest is controlled and that the crop has been improved in quality or quantity (yield data). There must be no doubt that if the product is used for the intended purposes and according to the tested methods, it is a worthwhile product.

THE PESTICIDE LABEL REVIEW

After all of the tests described above have been completed, the test results (data) in support of the proposed label are sent to the Pesticide Regulatory Division of the Environmental Protection Agency in Washington, D. C., for review to determine the utility (use) of the new compound. If the use is accepted, the pesticide is certified as being of value for the purpose or purposes claimed. These results are passed on to the Tolerance Section where the toxicology, residue, metabolic, and environmental data on the pesticide are reviewed. If the pesticide passes this thorough examination by the Tolerance Section, then tolerance levels are published in the Federal Register.

The next step is a final overall review by the Pesticide Regulation Division to determine if enough data have been presented to support all the claims on the label.

INFORMATION FOUND ON PESTICIDE LABELS

LABELS AND LABELING

Before discussing the specific information found on pesticides labels, it is necessary to distinguish between the terms "label" and "labeling." The label is the information printed on or attached to the pesticide container or wrapper. Labeling is a more inclusive term and refers both to the actual label and to all additional product information such as brochures and flyers provided by the manufacturer and handouts provided by the dealer. This material must not differ in meaning from hte information the manufacturer gave the EPA when the product was registered for use. Both the label and supplementary labeling are legally-binding documents and must be followed explicitly.

NAME OF THE PESTICIDE

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

BRAND NAMES

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

TRADE NAME

A trade name is a registered name used by a company for a specific pesticide formulation. Sevin 80W and Sevimol -4 are two different trade-named pesticides that contain the same active ingredient, carbaryl, formulated by the same company.

Cygon 267 and DeFend are two different trade names for pesticides containing dimethoate that are formulated by two different manufacturers.

APPROVED COMMON NAMES

An approved common name is given to the active ingredient of a pesticide that has been formally adopted by official agencies and societies. AAtrex 80W contains atrazine as its active ingredient.

CHEMICAL NAMES

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

THE INGREDIENT STATEMENT

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

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

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

SAMPLE LABEL: FRONT ▶

RESTRICTED USE PESTICIDE
For retail sale to and application only by certified applicators or persons under their direct supervision.
Contents 5 Gallons

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

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

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

INERT INGREDIENTS 72.8%
Contains 2 lb. abadabra acid equivalent per gallon
U.S. Patents 1234567 and 12345678

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

MINNY CHEMICAL COMPANY, Inc., Weedtown, Minnesota
EPA Reg. No. 4242XX
EPA Est. No. IIIX22
®Registered Trademark, Minny Chemical Co.

SAMPLE LABELS: REAR OR SIDE PANELS

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

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

USE ONLY ACCORDING TO DIRECTIONS ON THIS LABEL.

DO NOT FREEZE.

WARRANTY

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

DIRECTIONS FOR USE

How Much to Use

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

When to Apply

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

USE PRECAUTIONS

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

CAUTION!!

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

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

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

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

LOT 11111

NET CONTENTS

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

USES

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

DIRECTIONS

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

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

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

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

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

WARNINGS AND PRECAUTIONS

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

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

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

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

CLASSIFICATION

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

APPLICATION OF PESTICIDES

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

TYPES OF FORMULATIONS

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

EMULSIFIABLE CONCENTRATES (EC)

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

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

HIGH CONCENTRATE LIQUIDS, SPRAY CONCENTRATES

These formulations may be thought of as special EC formultions. They usually contin a high concentration of the active ingredient, as much as 8 or more pounds per gallon.

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

LOW CONCENTRATE LIQUIDS OR OIL SOLUTIONS

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

FLOWABLES (F OR L)

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

SOLUTIONS AND WATER SOLUBLE CONCENTRATES

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

ENCAPSULATED PESTICIDES

This is a relatively new method of formulating pesticides. The active ingredient is encased in extremely small capsules made of inert synthetic polymers; the capsules are then suspended in a liquid. Application is made with conventional sprayers after diluting the formulation with water. Encapsulated material can be handled with relative ease and safety. They may, however, pose a significant hazard for bees since capsules may be taken back to the hive with pollen.

AEROSOLS

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

PRESSURE LIQUIFIED GASES AND FUMIGANTS

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

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

One of the most common stored grain fumigants is phosphine. It is inserted as a solid capsule into the grain mass where where it picks up moisture. The pellet and plus the moisture causes the release of phosphine which is toxic to insects and other organisms.

Vapors of fumigants are highly toxic and must not be inhaled. Most fumigants can also burn the skin; if any fumigant in liquid form contacts the skin, it must be washed off immediately. Contaminated clothing should be changed at once. When applying fumigants, proper techniques must be followed and all recommended protective clothing and equipment must be worn.

DUSTS (D)

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

GRANULES (G)

Granular formulations are dry formulations usually made by applying a liquid formulation to granules of clay or other porous materials such as corn cobs or walnut shells. The granules are prepared in advance to a standard size before the liquid formulation is applied. The liquid is absorbed or absorbed (or both) on the porous material. Additional adjuvants or conditioning agents may be added to granular formulations so they handle well. The percentage of active ingredient in granular formulations is lower than that of an EC but usually higher than that of a dust. From the applicator's standpoint, they are usually safer to apply than EC's or dusts. Granular pesticide formulations are most often used as soil treatments. They can be applied directly to the soil or over plants, since they do not cling to plant foliage, although they can be trapped in the whorls of some plants.

WETTABLE POWDERS (WP)

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

SOLUBLE POWDERS

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

DRY FLOWABLES

Dry flowable formulations have the appearance of granules but contain very high concentrations of active ingredient and are used in the same manner as wettable powders. They are made to be mixed to form a spray suspension. They have several advantages over wettable powders. First, they can be poured from their container and can be measured by volume like a liquid. They are safer to handle because there is little dust to disperse in the air while measuring and mixing. The granules contain wetting and dispersing agents just like the wettable powders, and therefore, readily disperse to form the spray solution.

POISONOUS BAITS

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

INCOMPATIBILITY

It is not sufficient to simply establish that a mixture of two or more pesticides is, in theory, desirable. You must be sure that they can be mixed together without reducing their safety or effectiveness. When two or more pesticides can be effectively mixed without a loss in activity, an increase in toxicity or hazard to the applicator, or harm to the crop or the environment, they are said to be compatible; if they cannot be effectively mixed they are said to be incompatible. Incompatibility can be either physical or chemical.

PHYSICAL INCOMPATIBILITY

Some pesticides are incompatible simply because they cannot physically be mixed together; this is referred to as physical incompatibility. Physical incompatibility usually involves either a precipitation or deposit of solid material at the bottom of the spray tank or a separation of components into two or more layers following agitation. In some instances, separate elements may come together to form larger aggregates, or "foaming" or "curdling" may occur. Physical incompatibility may result in either an unsprayable mixture or in the application of varying concentrations of the component materials.

If a tank mix of two or more pesticides is specified on a product label, there should not be compatibility problems. Where a pesticide is registered for use with fluid fertilizers, however, effective mixing may depend on the nature of the specific fertilizer you are using. It is, therefore, extremely important that you determine whether a particular combination is physically compatible by followinng the testing procedures outlined on the product label. In some instances, the addition of a compatibility agent may provide more effective mixing.

INSECTS ATTACKING CROPS

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

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

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

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

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

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

PRINCIPLES OF CONTROL

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

DETECTION

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

IDENTIFICATION AND DIAGNOSIS

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

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

ECONOMIC EVALUATION

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

KNOWLEDGE ABOUT LIFE HABITS OF PESTS

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

DEVELOPMENT AND IMPROVEMENT OF CONTROL METHODS

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

PRESCRIPTIONS OR RECOMMENDATIONS

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

IMPLEMENTATION

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

EVALUATION, RECORDING, AND IMPROVEMENT

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

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

METHODS OF CROP INSECT CONTROL

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

CULTURAL CONTROL

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

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

BIOLOGICAL CONTROL

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

MECHANICAL-PHYSICAL CONTROL

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

LEGAL CONTROL

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

CHEMICAL CONTROL

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

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

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

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

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

PLANT DISEASES

CHARACTERISTICS

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

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

Three ingredients must be present for a disease to develop:

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

CAUSES OF PLANT DISEASES

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

NONPARASITIC

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

PARASITIC

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

FUNGI

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

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

BACTERIA

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

VIRUSES

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

NEMATODES

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

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

DEVELOPMENT OF DISEASES

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

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

SYMPTOMS OF PLANT DISEASES

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

1. **Necrosis** is the actual death of cells or entire portions of the plant. Necrotic tissue is usually discolored, frequently appearing brown or black. The necrosis may be general, involving extensive decay or rotting (e.g., dry rots, soft rots, brown rots, white rots) or it may affect only small areas, sometimes only a few cells (e.g., leaf spots, fruit spots, blotches, scabs, stripes, streaks).

2. **Overdevelopment of tissue** is the result of either increased cell division (hyperplasia) or abnormal enlargement of cells (hypertrophy). Examples are galls, clubroot, leaf curls, and warts.

3. **Underdevelopment of tissue** is the result of either decreased cell division (hypoplasia) or enlargement (hypotrophy). Examples are stunting, dwarfing, and some malformations.

4. **Discoloration of tissue**, apart from that resulting from necrosis, is usually due to either the failure of chlorophyll to develop properly or to its abnormal breakdown. Yellowing (chlorosis) of normally green tissue is generally the observable symptom, although occasionally a red discoloration may occur. Chlorosis is a characteristic symptom of many diseases, particularly during the early stages of disease development and may be followed by necrosis. Frequently, the pattern of the chlorotic area is useful in diagnosing the disease, particularly where viruses are the causal agents. Chlorosis is often a secondary symptom resulting from damage to another part of the plant, particularly the roots.

5. **Wilt** is the loss of rigidity and drooping of plant parts, usually resulting from insufficient water transport to the aerial portions of the plant. It may be due simply to low soil moisture or it may be the result of necrosis of roots or stems or plugging of the plant's conductive tissue due to the activities of the pathogen.

Definitions of a number of specific plant disease symptoms are included in the glossary at the end of the manual.

Plant diseases are often classified according to characteristic symptoms or signs, e.g. blights, mildews, rots, mosaics.

Identifying Plant Diseases

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

We should first attempt to determine whether the disease is caused by a pathogen or an environmental factor. You must always consider when and under what circumstances the disease appeared, whether or not it seems to be spreading, previous cultural activities (e.g. cultivation, fertilization, irrigation, pesticide applications) and the common disease problems of the crop and area.

Note how the diseased plants are distributed over the affected area. Definite patterns of distribution such as the edges of a field, along roadways or fences or in low spots often suggest that either climatic conditions, soil factors, or toxic chemicals are involved, but do not necessarily exclude pathogenic agents. Are the affected plants distributed randomly or in spots in the field of are they limited to a particular row or rows? The latter might indicate errors in cultivating, fertilizing, or applying pesticides. Are all of the plants in a field affected? Pathogenic diseases progress with time and rarely affect 100% of the host plants in the same manner at any one time. When a problem affects all, or nearly all, of a plant population, the cause of the problem is frequently an excess or deficiency of soil nutrients, adverse climatic conditions, toxic chemicals, or poor cultural practices.

How did the disease develop? Did it appear overnight? If so, this would suggest an abiotic cause. If, however, the condition started at one point in time and subsequently spread slowly in extent and severity, a pathogenic agent is probably responsible.

In examining symptoms, you must determine the appearance of a typical diseased plant. Don't rely simply on symptoms produced during the early stages of a disease and certainly, don't rely on a plant that has deteriorated to the point where the death of plant tissues makes the identification of characteristic symptoms impossible. Always compare what is thought to be a diseased plant; normal structures and characteristics can sometimes be mistakenly viewed as evidence of disease.

In looking at disease symptoms, always examine the **entire** plant. We have already noted that above-ground symptoms, particularly chlorosis and wilting, are frequently the results of damage to the root system. Always examine the roots of a diseased plant if you are at all unsure of the cause. It can also be helpful to cut into or through portions of diseased plants. For example, vascular wilts are often characterized by a browning of the conductive tissue of a plant; the discoloration can often be seen with relative ease if you cut through portions of the stem.

A small hand lens, a pocket knife, and a shovel can be invaluable tools for disease diagnosis.

If you are unsure of the cause of a disease--ask for **qualified** help. Assistance is readily available from your county extension agent; if necessary, he will send a disease specimen to the Department of Plant Pathology's Disease Diagnostic Clinic in St. Paul for positive identification.

PRINCIPLES OF CONTROL

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

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

- Avoidance of the pathogen.
- Exclusion of the pathogen.
- Eradication of the pathogen (and its vectors).
- Protection of the host from the pathogen.

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

EXAMPLES OF CONTROL

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

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

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

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

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

WEEDS

CHARACTERISTICS

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

Weeds are a problem because their presence can mean:

- Reduced crop yields
- Less efficient land use.
- Reduced product quality.
- Diminished enjoyment of outdoor recreation.
- Spoiling of the beauty of turf and ornamental plants.

State and local ordinances allow certain plants to be legally declared weeds. Marijuana, poison ivy, bull thistle, perennial sow thistle, musk thistle, plumeless thistle, Canada thistle, field bindweed, and leafy spurge have been designated as "noxious weeds" by Minnesota state regulations, and as such must be cut or controlled so that seed production does not occur. Some local governments require control of additional weeds.

WEED NAMES

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

LIFE CYCLES

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

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

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

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

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

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

Perennial plants can be further grouped as:

> **Creeping perennials**, which produce seeds but also produce rhizomes (belowground stems) and stolons (aboveground stems). Examples incude quackgrass, Canada thistle, and field bindweed.
>
> **Simple perennials**, which produce seeds each year as their normal means of reproduction (in some instances, root pieces may produce new plants following mechanical injury during cultivation). Examples include dandelions and plantain.
>
> **Bulbous perennials**, which produce seeds and bulbs that can form aboveground bulbs (wild garlic) or belowground bulbs (wild onions).

PRINCIPLES OF WEED CONTROL

Here are some common terms you should know before planning weed control. We have already noted that our most common and troublesome agricultural weeds are species adapted to invade and survive on cultivated land. Their capacity to prosper in these environments is due in large part to highly efficient mechanisms for survival and dissemination, mechanisms which make effective control extrememly difficult.

Annual and biennials depend exclusively on seed for reproduction and survival. Destruction of the top of the plant by mowing, tillage, herbicides or other means is, in most instances, an effective method of control. It is important, however, that the growing point be killed; for this reason, it is often more difficult to control grasses in this fashion than broadleafs simply because the growing point in grasses is often at or below ground level. Annuals are rarely capable of resprouting from their roots; some biennials, however, such as musk and plumeless thistles, do have the capacity for significant regrowth.

It is much more difficult to effectively control perennials by simple destruction of the top growth. We have already seen that most perennials have specialized underground structures which may serve for both reproduction and survival. Destroying top growth on a one-time basis will normally not kill the plant unless done in the seedling stage before underground survival structures have developed. It will simply produce new growth using food stored in these underground structures. Destruction of top growth can only be effective if done repeatedly; eventually the supply of stored food will be depleted to the point that regrowth is no longer possible. Even with simple perennials such as dandelions, which reproduce only by seed, sufficient energy for effective regrowth is normally stored in the roots. It should be obvious that the most effective methods of perennial weed control are those which destroy the underground survival and reproductive structures. This can be done by tillage, although it is often difficult, or by the use of appropriate herbicides.

Whether you are attempting to control annuals, biennials, or perennials, it is extremely important to prevent seed production. Weed species often produce enormously large numbers of seeds. For example, a single pigweed plant may produce 100,000 seeds. Weed seeds are often notably tolerant of extremes in temperature, wet and dry conditions, and variations in oxygen supply and may remain alive in the soil for a great many years. Only a small percentage of the seeds of most weed species germinate in any single year. The remaining seeds stay dormant and continue to germinate in succeeding years. Proper temperature and the availability of oxygen and light influence germination; this partially explains the new population of weeds that often emerge after each cultivation. Weed seeds are effectively spread by wind, water, animals (including man), or machinery, and in crop seed, feed grain, hay, straw, and manure.

In cultivated crops, the weeds that are favored by crop production practices are usually the most serious problems. The production method, especially the use or nonuse of cultivation, is often more important in determining the size and kind of weed problem than is the particular crop species.

Weeds with physical characteristics, growth habits, soil, water, nutrient and light requirements, and life cycles that closely resemble those of the crop are usually the most serious problems. Broadleaf weeds are often most difficult to control in broadleaf crops, and grass weeds in grass crops. Control of a particular weed should be considered only as a part of a total weed control program and, for that matter, of a total pest control program. A weed control program should be planned well in advance of the growing season. It should be based on a thorough knowledge of weed problems, soil characteristics, future cropping plans, and all available methods of control. As crop production practices change, so do weed problems; a good weed control program must be flexible.

METHODS OF WEED CONTROL

Man has faced weed problems throughout recorded history. The crude wooden hoe dates back to 6000 B.C. Hand weeding, plowing, and harrowing were practiced before the time of Christ. Planting crops in rows to permit "horse-hoeing" was a practice that began with the ideas of Jethro Tull in 1731. Many of the basic methods of weed control used today have changed very little over the years.

CLEAN SEED Weeds often get their start in fields from a few seeds planted along with the crop. Most weed seed can be separated from crop seed by proper cleaning and separation. Only tested and tagged seed should be planted; certified seed insures high quality seed free of noxious weeds. It is often easier to prevent the introduction of weeds than it is to control them once they've become established.

CLEAN FEED Weeds can easily be spread by feeding grains and forages which contain weed seeds. Most weed seeds germinate quite well after passing through farm animals, and manure spread on fields can be an effective means of dissemination. Screenings containing weed seeds are sometimes used in mixed feeds; unless they have been finely ground or heated, the weed seeds may be viable.

TILLAGE Tillage may involve either simple burial of weeds or destruction of the plant or plant parts, particularly the root system and other underground structures. Burial can be effective for small annuals and biennials, but will not control most perennials if they are beyond the seedling stage, unless done repeatedly. Sweeps, knives, harrows, rotary hoes and other shallow cultivation equipment can be used for effective destruction of underground structures. Control of this type is most effective in dry soils where roots have little chance of becoming reestablished.

Tillage will, however, often result in the germination and emergence of a new population of weeds, primarily from seeds that have been brought near the soil surface. If this occurs prior to planting, increased control, particularly of annual weeds, can often be achieved with a subsequent cultivation. The crop should be planted immediately after the last cultivation to allow sufficient growth before weeds again become a problem.

MOWING Mowing is effective only for tall-growing weeds and is used principally to reduce competition with crop plants and to prevent seed production. It is feasible to deplete the food reserves of certain tall perennials to the point where regrowth is no longer possible; this is difficult to achieve, however, and requires repeated and frequent mowing.

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 either crowded out or, at the very least, the crop becomes a formidable competitor.

CROP ROTATION Crop rotation tends to limit the population levels of certain weed species normally associated with a particular crop or crops. A rotation that utilizes crops with different life histories or growth habits will help control weeds that are not adapted to the production practices used for any one of the crops. For example, many summer annual weeds associated with corn will not do well under the cultural practices of fall-planted small grains. Although crop rotations that keep land in almost continuous use may be desirable, special weed problems may often be partially solved by allowing intervals for fallowing or nonselective chemical treatments.

COMPANION CROPS

Plant species (usually annuals) which germinate quickly and grow rapidly are sometimes planted with a perennial crop to compete with weeds and allow the major crop to become established. The companion (or nurse) crop is then removed or harvested to allow the perennial crop to take over. For example, oats is often used as a companion crop in Minnesota to aid in establishing a crop of alfalfa.

BIOLOGICAL CONTROL

Biological weed control can have long-range effects on weed populations but few such methods have proven successful in agricultural crop production thus far. It, nevertheless, offers at least the potential for some future success.

All weeds have natural enemies, the same groups of natural enemies we consider pests of our crops. Insect and plant diseases are the most important groups of natural enemies. When these natural enemies are absent, or are rendered ineffectual due to production practices, the weeds may grow unimpeded. Over one-half of the major weeds in the U.S. have been introduced from other areas of the world and are growing free from most, if not all, of their natural enemies. Biological control specialists are attempting to correct this situation by searching out natural enemies and introducing them into areas where a particular weed is prevalent. Although complete control can probably not be expected from the use of biological control agents, they may reduce a weed's competitive ability and render it more susceptible to other means of control. Attempts have been made in Minnesota to achieve some measure of control of musk thistle through the release of a particular species of weevil but, thus far, these attempts have not been successful.

CHEMICAL CONTROL

Since World War II, the use of "herbicides" has come to be the most common method of weed control in agriculture. Herbicides are discussed in detail in the various weed control fact sheets available from your county agent. Your county agent can provide you with the weed control fact sheets for the crops you plan to grow.

HERBICIDES

Here are some common terms you should regarding herbicides:

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

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

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

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

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

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

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

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

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

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

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

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

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

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

We again need to emphasize that a weed control program should be based on a thorough knowledge of weed problems and that control measures should be applied only when they are truly necessary. It should employ the method or combination of methods which will give the most effective, practical, economical, and environmentally sound weed control.

FACTORS AFFECTING CONTROL

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

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

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

Environmental Factors--Soil moisture and rainfall affect herbicide activity and disappearance from soil and plants. Good soil moisture conditions allow the highest levels of herbicide activity. Dry conditions may cause the herbicide to evaporate, whereas wet conditions may keep the herbicide from contacting soil particles. Warm, moist soil may cause herbicides to disappear through microbial activity and chemical reactions.

Rainfall causes soluble herbicides to leach downward into the soil profile, a process that may be desirable with relatively insoluble herbicides and undesirable with more soluble herbicides (due to possible crop injury). Heavy rainfall may result in poor weed control or possible crop injury, depending on the relative solubility of the herbicide.

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

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

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

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

Sunlight may destroy some herbicides if they are left on the soil surface for extended periods.

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

One weed may respond differently to different herbicides, and slightly different weeds within the same species may respond differently to the same herbicide. Weed response is also affected by plant age and rate of growth.

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

- Apply the lowest practical rate of herbicide.
- Apply the herbicide uniformly, avoiding double coverage. Equip sprayer nozzles with check valves and quick-closing cutoff valves for turns. Shut off the applicator when turning.
- Select crop sequences that are tolerant to the herbicide used on the previous crop.
- Rotate herbicides when the same crop is grown continuously, and rotate herbicides on all crops grown in a rotation.
- Spot treat when using high rates of herbicides for control.

VERTEBRATE PESTS

All vertebrate animals have a jointed spinal column (vertebrae). These "higher" animals include fish, amphibians, birds, and mammals. What may be a pest under some circumstances may be a highly desirable form under others.

FISH

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

Reptiles and Amphibians

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

Birds

Damage caused by birds can be varied. It includes structural damage by woodpeckers; killing of fish, livestock, poultry, or game species, and destruction of fruit, nut, grain, timber, and vegetable crops. Birds also can present hazards to animal and human health, as they can be hosts for disease organisms. Peck marks, location of damage, tracks, feathers, droppings, and evidence indicating that items have been carried away form the basis for determining bird depredation.

Mammals

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

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

PRINCIPLES OF CONTROL

To solve vertebrate pest problems, an applicator must:

- Recognize damage patterns and the species of animal responsible.

- Know the physical characteristics and life habits of most animal species present in a given situation.

- Be aware of the control measures available that would be effective, selective, humane, and cause the least possible environmental damage.

- Know the local, state, and federal regulations that apply to the situation.

- Realistically evaluate the risks and benefits of the available control measures.

POCKET GOPHERS

Except during the breeding season, gophers lead solitary lives and each adult occupies its own system of burrows. One adult may build as many as 100 mounds a year, moving as much as 2.25 tons of soil to the surface. The burrow system is two-story and may be as long as 200 feet. Tunnels are parallel with the soil surface and vary in depth by soil type from 6.24 inches for the feeding burrows to 5 or 6 feet for food storage and living chambers.

CONTROL

Great horned owls, barn owls, coyotes, foxes, badgers, weasels, rattlesnakes, and bull (gopher) snakes are a few natural enemies which help control gopher population. Predator action, however, does not severely limit or reduce gopher numbers. Disease and starvation also cause some mortality. Natural control mechanisms, while effective in terms of long-range population control, are usually insufficient for the short run.

On small acreage (10 acres or less) hand application of poison bait (strychnine alkaloid coated grain) during the fall is usually effective. Depending on the source of labor and the priority of control, initiation of a fall trapping program to complement baiting would give added control. Trapping would also be effective in the spring following a fall baiting program. Special pocket gopher traps are available at most nurseries, farm supply, and large hardware stores.

Machine baiting with the use of a burrow builder is the most practical means of control on areas larger than 20 acres. Fall and spring applications give the greatest control. The soil must be moist enough to allow the torpedo tube easy passage and to hold a neat burrow shape when compressed. Artificial burrows may vary in depth and that is less important than forming a neat tunnel. A tunnel depth of approximately 10 inches is desirable. Completely enclose the field to be protected by parallel rows of artificial burrows. Space these burrows at intervals of 25-40 feet; wide in spring, narrow in fall. Within three weeks of application 85-90 percent control can be attained by proper application of bait. Reapplications may be needed at two to four year intervals.

Strychnine is toxic to all animals and must be handled and applied according to label instructions. All applications must be below ground. Clean up all spilled bait. One pound of bait per acre of treated land is sufficient to gain control, additional bait beyond this rate is wasted.

Many counties own burrow building machines. To schedule the use of one, check at the county office of your Agricultural Extension Service, Soil Conservation Service, or Soil and Water Conservation District.

Endangered and Threatened Species

The federal government provides special protection to species which are endangered or threatened. In Minnesota, the Gray Woly and the Bald Eagle are classified as endangered and the Peregrine Falcon is threatened. These species are fully protected by federal law. Individuals can not kill or molest them if they become pests. If they do become a problem contact the U.S. Fish and Wildlife Service in your local area or call the St. Paul Office at (612) 725-3276.

FUMIGATING STORED GRAIN

Grain should not require fumigation during the first of year of storage in Minnesota, especially if proper sanitation and residual insecticides are used. Malathion can be applied as a residual insecticide to supplement some stored-grain insect pest management programs. Actellic is now approved for use as a protectant on harvested grain to be exported. Fumigation, however, may be justified if these insect prevention efforts fail.

Fumigants are formulated as solids, liquids, or gases but they all must be in the gaseous state to penetrate grain and kill the insects. None of the fumigants have long-term effectiveness; as soon as they diffuse away from the target area, insect reinfestation can follow immediately. Fumigant diffusion time depends primarily on the fumigant, dosage, the grain being fumigated, and the structure of the bin.

It is safer, less expensive, and usually more effective to have your stored grain fumigated by a licensed and certified professional than to do it yourself. This applies especially to single upright bins containing more than 5,000 bushels. Flat storage structures are usually more difficult to fumigate satisfactorily than upright bins because of their relatively large grain surface area where insects congregate and fumigants dissipate quickly.

There are several reasons to consider hiring a professional fumigator to conduct your fumigations. The most important is to your personal risk in handling a highly toxic pesticide. A professional fumigator will 1) have fumigating knowledge and experience, 2) have the special equipment required to apply fumigants, and 3) be aware of the safety devices (such as gas masks and concentration monitoring equipment). In fact EPA's proposed Label Improvement Program for fumigants may eliminate fumigation by nonprofessionals in the future.

The grain fumigant application method most often used on Minnesota farms involves pouring liquid-type fumigants onto the surface of the grain mass. Recommended dosages usually range from 2 to 5 gallons per 1,000 bushels of grain. Thus, 20,000 bushels would require a minimum application of 40 gallons of fumigant. Most Minnesota farmers (nonprofessional fumigators) would apply these liquid fumigants by inverting a sufficient number of 1- or 5-gallon containers of the fumigant into the grain surface. The time required for such an application to a grain mass of over 5,000 bushels could be dangerous for the applicator, especially if the correct type of gas mask were not worn properly.

Two people should always work together when fumigating. Both need adequate safety equipment. Adequate warning signs must be posted on grain bins during the fumigation and removed when it is safe to re-enter the fumigated area. Grain fumigants can still be used satisfactorily if the necessary safety measures are followed and the major factors (listed below) that alter the effectiveness of a fumigation are understood.

TEMPERATURE

Grain temperature is extremely important to the efficacy of a fumigation because it determines the speed of fumigant vaporization and penetration through the grain. Low grain temperatures (less than 50 F) slow down the vaporization rate and subsequent movement of lethal gas concentrations to the insects. Insect respiration is also reduced at temperatures below 50 F, resulting in reduced kill. As a result extended fumigation periods may be needed for successful fumigation. This adjustment for low grain temperature is often given on the label.

MOISTURE

High moisture corn (above 15%) or wheat (above 12%) retards the movement of the fumigant and may result in increased absorption into the grain kernals, reducing gas concentrations below those required to kill the insects and producing higher residues. Specific areas of high moisture grain will also result in nonuniform gas concentrations and questionable insect control.

BIN CONSTRUCTION

A fumigant must be held in the grain long enough as a gas at sufficient concentrations to kill insects. Tightly sealed metal or concrete structures may be required for some fumigants. Carefully caulked wooden bins may be satisfactorty. Covers of polyethylene or plastic-coated nylon over the top of the grain following fumigant application will help to ensure effective fumigation in some situations.

DEPTH OF GRAIN

The shape and depth of grain in the bin also affects the fumigant. Upright bins present a minimum of grain surface for the loss of the gas. A gas-tight cover should be used over grain in flat storages or when a bin is only partially filled.

VENTILATION

Most fumigants are heavier than air and sink through the grain. Penetration through the entire grain mass, especially in deep bins, can be assisted by using aeration. In fact, recirculation is necessary to fumigate with methyl bromide. Remember to seal off the aeration system during the actual fumigation. Aeration also can be used to remove the fumigant following the recommended exposure period.

DOCKAGE

Dockage in grain is an important variable affecting the efficiency of a fumigant. The sorptive capacity of grain will increase with increases in dockage. As grain is loaded into bins the light dockage (chaft, dust, etc.) settles around the outside of the grain mass while heavier dockage settles or is trapped in the spoutline area. This uneven distribution causes fumigants to channel through grain by flowing through areas of least resistance. In addition, insects usually congregate in areas of high dockage and therefore may escape lethal gas concentrations, especially if such areas are peaked above the remaining grain surface.

FUMIGANT AND DOSAGE

Although fumigant formulations vary in their efficiency, this variable is usually less important than the variables listed above. Regardless of which fumigant you select, you should always follow recommended dosages. Less-than-maximum labeled dosages may require refumigation. Excessive dosages are wasteful and can initiate unnecessary hazards.

FUMIGATION GUIDELINES

Effective fumigations result from following several recommended guidelines including the following:

- Level the grain below the vertical wall of bins.
- Remove or break up any crust on the grain surface.
- Seal all cracks, making the bin as airtight as possible.
- Fumigate when the grain temperature is between 70 and 90 F.
- Keep the bin closed and post warning signs until the bin is safe.
- DO NOT ENTER the bin during or after fumigation until gases have been removed.

SELECTING A FUMIGANT

The selection of fumigants for your particular need may be difficult. They vary in their chemical, physical, and biological properties. As a guideline, an ideal fumigant should have most of the following properties:

- low in cost per effective fumigation;
- toxic to all developmental stages of the target insects;
- highly volatile with good penetration power (but not be excessively absorbed by grain);
- easily detected, with adequate warning properties;
- noncorrosive, nonflammable, and nonexplosive under practical conditions, with good storage life;
- nonreactive with the commodity so as not to produce adverse odors or flavors;
- able to aerate readily, leaving no harmful residues;
- noninjurious to seed germination and not detrimental to the commercial grain grade;
- nondamaging to milling qualities or other processing properties of grain;
- readily available and simple to apply.

GRAIN STORAGE MANAGEMENT PRACTICES

The major factor leading to economically significant fungus or insect infestations in stored grain are: moisture content of grain, temperature of the grain, amount and concentration of cracked or broken kernels and foreign material, the degree to which the grain already has been invaded by storage fungi before it arrives at the storage site, and the length of time it is stored. All of these factors interact with one another and all of them are measureable.

Preventative measures such as bin sanitation and moistenous will aid in insect control. All cracks and crevices should be eliminated where possible. Insecticides applied to bin walls, floors and, when applicable, to bin subfloor areas will help provide control of insects missed in cleanup. Never store new grain with old grain. Grain being stored for long periods can be further protected from insect invasion using insecticide grain protectant sprays or dusts.

The keys to good grain management are: drying the grain to safe moisture conditions, remove fines by screening and eliminate spoutbins, and proper aeration management. Aeration should be done to keep the temperature between 20 degrees (F) of the average monthly temperature between 25-35 degrees (F) in the winter and no higher than 60 (F) in the summer. This will prevent moisture migration and prevent insect and mold infestations.

GRAIN PRESERVATIVES

High moisture corn can be protected from spoilage by treatment with proprionic acid which is sold under various trade names. Formulations containing 80-100 percent proprionic acid are very effective against grain spoilage for a period of up to year. For best results it is important to follow the label rates and to use an application method that will evenly distribute the compound over all the grain being preserved. Problems associated with this type of preservation arise from improper applications such as too low a rate for moisture content of the grain or moisture migration due to improper management of the preserved grain.

It is important to note that proprionic acid-preserved grain should be managed the same way as dry grain. Aeration can keep the temperatures of perserved grain uniform to prevent moisture migration. A variety of structures may be used to store preserved grain. However, experience shows that proprionic acid-treated grain stored in an upright cement silo has a higher tendency to go out of condition than when stored in other structures.

Anhydrous ammonia can be used to preserve high moisture corn while drying with unheated air. Intermittent applications of ammonia at low levels will suppress mycrobial deterioration during the drying process. This process, which has environmental protection agency approval, will control toxigenic microorganisms and can be operated over a wide range of weather conditions.

Grain preserved either by proprionic acid or anhydrous ammonia can only be used for animal feed and it is not permitted in commercial channels.

REENTRY INTERVALS

Pesticide residues on a treated crop or in a treated area may pose a significant hazard for workers or others who reenter the area prematurely; a substantial number of pesticide poisonings have been due to premature reentry. This is particularly true where there may be appreciable contact with treated foliage.

The reentry safety interval has been defined by the Environmental Protection Agency as "the length of time that must expire after pesticide application before people who are not using personal protective equipment can enter the treated site without being likely to experience any adverse effect due to exposure to pesticide residues". Intervals vary according to the characteristics of the pesticide and the crop or area treated.

At present, reentry safety intervals are not required on most pesticide labels; this may change in the near future. Whether or not it is specified on the label, however, you must observe a reentry interval of at least the designated number of hours for the pesticide active ingredients listed below; if the label indicates a longer reentry interval, the labeled interval must be observed.

Active ingredient	Reentry interval (hours)
Azinphosmethyl	24
Carbophenothion	48
Demeton	48
Dicrotophos	48
Endrin	48
EPN	24
Ethion	24
Ethyl parathion	48
Methyl parathion	48
Monocrotophos	48
Oxydemeton-methyl	48
Phosalone	24

There are some exemptions from the above restrictions including livestock and other animal treatments, greenhouse treatments, and treatment of golf courses and similar nonagricultural areas provided the application is made in accordance with label directions and restriction.

Where the product does not contain one of the active ingredients listed above and where the label does not specify a reentry interval, use good judgment. Never reenter a treated area without protective clothing and/or equipment before a spray has dried or a dust has completely settled. Be sure that others stay out of the treated area as well--particularly farm workers and children.

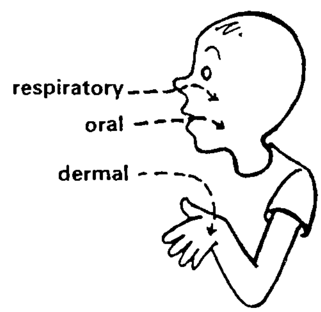
TOXICITY

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

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

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

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



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

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

Since LD/50 means lethal dose for 50 percent of the test population, we must assume that it represents an approximation, or average, of the effect of the compound. Further, since a limited number of species of lab animals are used, great care must be used in applying such findings to humans. They should be used in a relative way for general guidance only.

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

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

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

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

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

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

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

ORGANOPHOSPHATES

The organophosphates, because of their widespread use and frequently high acute toxicity, are responsible for more pesticide poisonings than any other class of pesticides. We have already indicated that the organophosphates interfere with the activity of an enzyme known as cholinesterase which is necessary for proper nerve functioning. When the enzyme is unable to perform its normal function, the nerves in the body send "messages" to the muscles continuously. Muscle "twitching" and weakness is a common result; if the poisoning is sufficiently severe, the victim may have "fits" or convulsions and death may result.

Organophosphates are **irreversible** cholinesterase inhibitors; without medical treatment, enzyme activity will return to normal levels only after a period of several days, weeks, or even months. Symptoms may become apparent almost immediately after exposure to some organophosphates (e.g. mevinphos or TEPP); with others, symptoms may be delayed for several hours (e.g. parathion, azinphosmethyl, or phorate). The initial appearance of symptoms more than 12 hours after exposure excludes the possibility of acute organophosphate poisoning.

Because the organophosphates act as irreversible enzyme inhibitors, the additive effects of small repeated doses over the course of the growing season may finally produce symptoms of poisoning. It is much to your advantage not to allow things to progress that far. The normal or "baseline" level of cholinesterase in your blood can be determined by a relatively inexpensive test; have this done before the growing season if you plan to use organophosphates on a regular basis. Periodic blood tests during the growing season will then establish whether any harmful effects have occurred. Your family doctor should be able to give you further information. **Remember, long-term additive poisoning can occur in its initial stages in the absence of apparent symptoms.** A small additional dose can produce illness; a larger dose could be fatal.

The signs and symptoms of organophosphate poisoning may progress through different stages with the ultimate severity dependent principally on the level of exposure; common symptoms associated with organophosphate poisoning are given below.

Mild Poisoning	**Moderate Poisoning**	**Severe Poisoning**
Fatigue	Unable to walk	Unconsciousness
Headache	Weakness	Severe Constriction of pupil of eye
Dizziness	Chest discomfort	Muscle twitching
Blurred vision	Constriction of pupil of eye	Secretions from mouth and nose
Excessive sweating and salivation	Earlier symptoms become more severe	Breathing difficulty
Nausea and vomiting stomach cramps or diarrhea		Coma and Death

CARBAMATES

The mode of action of the carbamates is very much the same as that of the organophosphates. They are also cholinesterase inhibitors. Unlike the organophosphates, however, their action is naturally reversible. They can cause severe acute poisoning but since their inhibitory effect is reversible, they don't normally produce long-term, cumulative poisoning. Blood tests to establish cholinesterase levels are of relatively little value.

The symptoms of carbamate poisoning are essentially the same as those produced by the organophosphates.

CHLORINATED HYDROCARBONS

Although the mode of action of the chlorinated hydrocarbons is not entirely clear, it is known that they act either to stimulate or depress the central nervous system. Signs and symptoms of toxicity therefore vary with the specific chemical but may include nausea, mental confusion or semiconsciousness, jerking of limbs, dizziness, weakness, lethargy and diarrhea. Convulsions or extreme nervousness may occur in cases of severe poisoning. Symptoms have been reported as soon as 30 minutes after massive exposure, but generally develop more slowly; if maximum symptoms are not reached within a few hours after acute exposure, another cause should be considered likely.

The chlorinated hydrocarbons are generally not as acutely toxic as the organophosphates and carbamates, and fewer cases of occupational poisoning have occurred. Many do, however, accumulate in the fatty tissues of the body and it is important that exposure be kept to a minimum.

DINITROPHENOLS

Compounds in this group are used as fungicides, insecticides, and herbicides. Nitrophenol poisoning accelerates certain body processes and may cause fever, sweating, rapid breathing, rapid heartbeat, or unconsciousness. Dermal exposure to nitrophenols may produce redness of the skin, burning, and blisters. The effects of acute poisoning normally develop and run their course quite rapidly; death or nearly total recovery within 24 to 48 hours is the general rule.

BIPYRIDILIUMS

The bipyridiliums are contact herbicides (e.g., paraquat, diquat) which can be harmful if inhaled or absorbed through the skin and may be fatal if swallowed. Severe irreversible lung damage can develop if they are swallowed. All cases of paraquat ingestion and cases where large amounts have been spilled on the skin must be considered potentially serious and must be brought to the attention of a physician immediately. The doctor should be urged to contact the Chevron Chemical Company's Poison Information Center at 415-233-3737 for professional assistance; a supply of the antidote, bentonite clay, if needed; and analytical support.

ANTICOAGULANTS

The anticoagulants are used exclusively as rodenticides. They inhibit the formation of a compound responsible for blood clotting and also cause internal bleeding. For the most part, the anticoagulants are relatively safe to use since repeated exposures are required to produce serious illness. Initial symptoms of chronic poisoning are back and abdominal pains, nosebleeds, bleeding gums, and blood in the urine.

BOTANICALS

The plant-derived organic pesticides or botanicals vary greatly in their chemical structure and also in their toxicity to humans. Despite their natural derivation, however, some are quite toxic; strychnine, for example, is one of the most toxic of all pesticides.

INORGANICS

Acute doses of most inorganic pesticides cause vomiting and stomach pain. The exact nature of the symptoms varies somewhat with the particular compound, but in nearly all cases the illness is long-lasting.

FUMIGANTS

Most fumigants are highly toxic and extremely dangerous when inhaled; they must always be used with extreme caution. Symptoms of exposure to the less toxic fumigants are similar to those of drunkenness--poor coordination, confusion, and drowsiness.

Methyl bromide is perhaps the most widely-used fumigant. It is particularly dangerous because it is both highly toxic and odorless. Symptoms of poisoning are severe chemical burns of the skin, respiratory tract, and other exposed tissue; delayed chemical pneumonia (which produces water in the lungs); and severe kidney damage. Victims may also experience extreme nervousness. Any of these effects can be fatal. If smaller amounts of methyl bromide are inhaled, symptoms are again similar to drunkenness. Repeated mild exposures are cumulative and produce skin rashes, sometimes followed by mental confusion, double vision, tremors, slurred speech, and a lack of coordination. Victims have been jailed or sent to mental hospitals when their condition was misdiagnosed.

Chloropicrin, another commonly-used fumigant, is also highly toxic, but unlike methyl bromide, it has a strong odor and is very irritating to the eyes. It is also used as a tear gas. Because of its strong odor, it is frequently mixed with methyl bromide as a warning agent.

No alcoholic beverages should be consumed for 24 hours before and after a fumigation; this is a standard practice among professional fumigators. Alcohol tends to increase sensitivity to fumigants and can also interfere with proper diagnosis of fumigant poisoning.

CHRONIC EFFECTS OF PESTICIDES

We have already indicated that chronic exposure to small, repeated doses of a pesticide over a period of time, and that the corresponding ability of the pesticide to cause harmful effects is referred to as its "chronic toxicity". Unlike acute poisoning, which generally causes rapidly developing and easily recognized symptoms, symptoms of chronic poisoning may not become evident for a very long time. When the symptoms finally develop, they may not be associated with exposure to a toxicant that may have occurred months or even years before.

We have already noted that small, repeated doses of pesticides such as the organophosphates and methyl bromide may produce cumulative effects which finally result in illness. The symptoms normally appear, however, in the same growing season and the nature of the symptoms is quite different from those that concern us here.

There has been increasing concern in recent years that certain pesticides may produce serious, long-term effects such as cancer, birth defects, and sterility. It might be well at the outset to define a number of terms which are often used in discussions of chronic effects:

- A **carcinogen** is a substance which has the ability to cause cancer.
- An **oncogen** is a substance which has the ability to cause tumors; the tumor may or may not be cancerous.
- A **mutegen** is a substance which tends to increase the frequency or extent of mutations; mutations are changes, usually harmful, in inherited genetic material.
- A **teratogen** is a substance which has the ability to cause birth defects.
- A **fetotoxic** substance is one which can cause harm to the developing fetus; the effect is often lethal.
- A **neurotoxic** substance is one which has the ability to damage the nervous system.

Most of the concern regarding possible chronic effects of pesticides has been generated as a result of studies on laboratory organisms. There is very little conclusive evidence on chronic effects in humans. It is exceedingly difficulty to obtain reliable information; individuals who are exposed to certain pesticides must be clearly identified at the outset and their health must be monitored for a number of years or even decades.

A number of pesticides have been shown to be teratogenic and/or mutagenic in laboratory organisms but it is still unclear whether they cause similar effects in humans. Evidence suggesting that some pesticides could be involved in human cancer is somewhat stronger, although still not conclusive. At a recent conference sponsored by the American Association for the Advancement of Science, it was concluded that "although there is no direct epidemiological evidence that pesticides will cause cancer, the indirect evidence implicates them strongly... No one would deny that pesticides have the potential to cause cancer in humans, but whether this potential is actually realized remains to be documented".

It is clear that in any attempt to determine whether pesticides actually do produce chronic effects in humans, it is necessary not only to establish that they have the potential to do so but also that the level of documented exposure is of the required magnitude.

APPLICATION EQUIPMENT

The choice of appropriate application equipment and its proper operation and maintenance are perhaps as important to effective pest control as the selection of the pesticide itself. The substantial investment involved requires that the choice be based on a thorough familiarity with all alternatives, including the most recent developments in application technology. Many problems of current concern (e.g. drift, nonuniform coverage, failure of a pesticide to effectively reach the target organism, selective control) are at least partially solvable through the development of new application techniques and equipment. When you choose application equipment, be sure that it is well adapted for your purposes, that it is cost effective, that it has maximum efficiency, and that it will apply materials in an environmentally sound manner.

METHODS OF APPLICATION

Before discussing specific types of application equipment, we need to review briefly the various ways in which pesticides can be applied. The particular method of application chosen depends on the nature and habits of the target pest, the crop, the pesticide, available application equipment, and the relative cost and efficiency of alternative methods. The method of application is often predetermined by one or more of these factors, although there is frequently a choice between two or more methods. Always bear in mind that your principal objective is to effectively bring the pesticide into contact with the target organism(s).

Common methods of application of pesticides to crops are outlined below; livestock applications will be discussed in a later chapter.

1. **Foliar application** is application of a pesticide to the aerial portions of either a crop or weed.

2. **Soil application** is application of a pesticide directly to the soil rather than to a growing crop or weed.

3. **Seed treatment** is coverage of seed with an insecticide and/or fungicide prior to planting.

4. **Broadcast application** is the uniform application of a pesticide to an entire field or area; it can be made either prior to or after emergence of the crop.

5. **Band application** is the placement of a pesticide in a strip either over or along the crop row; it may be made to the soil prior to crop emergence or to crop and/or weed foliage.

6. **Furrow application** is the placement of an insecticide or a fungicide in a narrow line in the soil directly over the seed at planting time; always read the label to be certain that a furrow application is

permissible--some insecticides, in particular, are toxic to seeds.

7. **Split-boot application** is the placement of a mixture of liquid insecticide and liquid starter fertilizer in the soil to the side of the seed at planting time; the mixture should be applied at least one inch on either side of the seed and at the same depth.

8. **Spot treatment** is application of a pesticide to small, discrete areas.

9. **Directed-spray application** is one in which an herbicide is directed specifically at target weeds in an effort to minimize contact with the crop.

10. **Soil incorporation** is the use of tillage implements to mix the pesticide with the soil.

11. **Soil injection** is application of a pesticide beneath the soil surface.

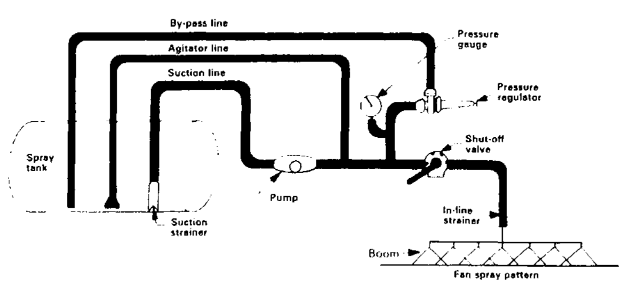
APPLICATION EQUIPMENT

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

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

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

Sprayer System



THE TANK

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

SPRAYERS

In selecting a sprayer, regardless of size, be certain that it is well adapted for your purposes. It must operate adequately when subjected to the abrasion of wettable powders and the deteriorating effects of some formulations on hoses, seals, tanks, etc. Effectiveness, durability, cost, and convenience in filling, operating and cleaning must be considered.

HYDRAULIC SPRAYERS

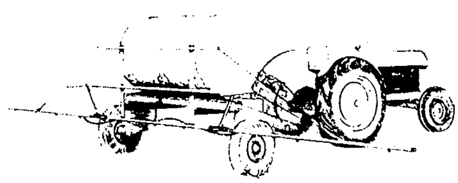
The basic operating principle of hydraulic spray equipment is the use of water as the means of transporting the pesticide to the target area. The normal procedure is to mix the pesticide with sufficient water to obtain the desired application rate at a specified pressure and travel speed. The liquid mixture is then forced through the spraying system under pressure and released on the target area.

LOW-PRESSURE SPRAYERS

Low-pressure sprayers are normally designed to deliver low to moderate volumes at 15-80 pounds of pressure per square inch (psi). Application is made through a boom equipped with nozzles. They are used primarily for weed and insect control on field and forage crops and on pastures where pressures up to 80 psi are sufficient for adequate coverage. They may also be used to apply liquid fertilizers or fertilizer-pesticide mixtures. They are usually mounted on either tractors, trucks, or trailers.

Small-tank sprayers (50-200 gallons) requiring low flow rates often are equipped with roller-type pumps. Sprayers with large tanks (200-1,500 gallons) requiring large flow rates for spraying and for proper agitation usually have centrifugal pumps. Centrifugal pumps have a long life, even where abrasive pesticides are used, but maximum spraying pressures are limited to 50-60 psi.

Low-pressure sprayers do not deliver sufficient volume to provide adequate coverage for some insecticides and fungicides and the spray cannot penetrate dense foliage because of low operating pressures.

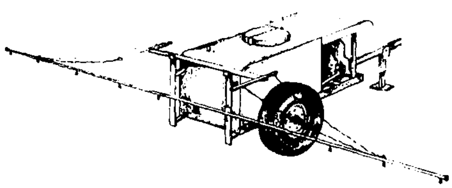


HIGH-PRESSURE SPRAYERS

High-pressure sprayers are designed to deliver large volumes at high pressure. They are similar to low-pressure sprayers except that they have piston pumps which deliver up to 50 gallons of spray per minute at pressures up to 800 psi. Application rates are normally 200-600 gallons per acre. Sprays are usually released by means of a boom or handgun. All components are designed and selected to withstand the high pressures.

High-pressure sprayers are used principally on fruits, vegetables, and trees for insect and disease control and may also be used to wash equipment. They provide thorough coverage and can penetrate dense foliage. They are usually well constructed and are long-lived if properly maintained, even with the use of wettable powders. They generally give good mechanical agitation. They are versatile, and when fitted with the proper pressure regulators, can be used at low pressures.

High-pressure sprayers are, however, expensive to buy and operate. They also use large volumes of water and, because they operate at high pressures, they have a tendency to produce large numbers of small spray droplets which may be subject to significant drift.



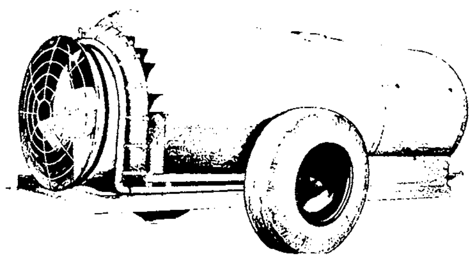
AIR-BLAST SPRAYERS

The operating principle of air-blast sprayers is the use of energy from a blast of air to propel sprays, in contrast to the use of large volumes of water for this purpose in hydraulic sprayers. Thus, only relatively small volumes of water are required. Nozzles deliver the spray into a high-velocity airstream generated by a powerful fan; the spray is broken into finer droplets and carried to the target area. The spray can be directed either to one or both sides of the machine. Airblast sprayers can deliver either high or low volumes of spray, but are generally used for relatively low volumes. They are used principally on fruit trees, vegetables, shade trees, and for fly control.

Air-blast sprayers provide good coverage and penetration and are lighter, use lower pump pressures, and are easier to operate than high-pressure sprayers. They are, however, quite expensive to buy and operate and produce a spray which may be subject to significant drift and which is difficult to confine to limited target areas. Calibration is critical for low-volume applications and favorable spraying weather is essential.

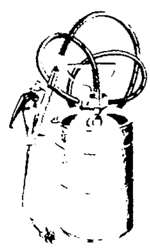
Special air-blast sprayers which have higher air velocities (120-200 mph) and lower air volumes are known as mist blowers.

They produce a finer spray and are normally used with lower water volumes than standard air-blast sprayers. There may be difficulty in achieving adequate coverage with mist-blowers, the potential for significant drift is greater, and accurate calibration may be even more critical.



SMALL-CAPACITY SPRAYERS

Small-capacity sprayers are designed for spot treatments, home and garden pest control, small tree and nursery spraying, and for restricted areas unsuitable for larger units. Most are hand sprayers which use compressed air to pressurize the supply tank, forcing the spray through a nozzle. Several types of small power sprayers are also available that deliver one to three gallons per minute at pressures up to 300 psi; adjustable handguns are usually used with these units, but spray booms are available on some models. Small-capacity sprayers are relatively inexpensive, simple to operate, highly maneuverable, and easy to clean and store. Adequate agitation and screening for wettable powders is, however, a frequent problem; and where there is direct reliance on the operator for the rate of movement over the target, there can be substantial variability in the application rate.



GRANULAR APPLICATORS

Granular applicators are designed primarily for soil applications. They range from crank-operated, spinning disc, backpack units which broadcast the granules, to field equipment designed for broadcast, band, or drill applications. Granules are normally applied either as a broadcast or band treatment before or at planting time and worked into the soil, or as a postplant side-dress application through drop tubes and fertilizer shoes. They may also be applied aerially by properly equipped fixed-wing or rotary-wing aircraft.

Although there are substantial variations in design, granular applicators normally consist of a hopper for the pesticide, a mechanical-type agitator at the base of the hopper to provide efficient and continuous feeding, and some type of metering device, usually a slit-type gate, to regulate the flow of the granules.

Drop-through spreaders are available in widths from 1 1/2 to 3 feet. An adjustable sliding gate opens holes in the bottom of the hopper and the granules flow out by gravity feed. Normally, a revolving agitator is activated when the spreader is in motion to assure uniform dispensing.

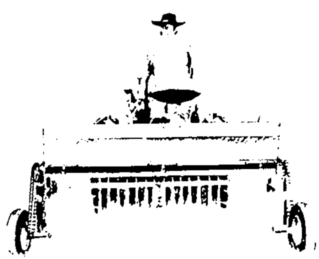
Rotary spreaders distribute the granules to the front and sides of the spreader, usually by means of a spinning disc or fan. Heavy granules are thrown further than lighter ones. A six to eight foot swath width is common. Both power- and hand-driven rotary spreaders are available.

Field units usually have an on-off lever which opens and closes the feeder gate; the lever may be designed either for manual operation or may be powered by the tractor hydraulic controls. Metering devices are usually controlled by either a dial with a set-screw or an adjustable lever with a large dial. On band applicators, adjusting the height of the spreader changes the width of the band.

In selecting a granular applicator, choose a unit that is easy to clean and fill. Be certain that it has good agitation over the outlet holes. Banders should spread the granules uniformly, even on side slopes of 10 to 15 percent. Chain drives should have sprockets of eight teeth or more to keep drive speed uniform. Design should be such that granule flow stops when drive stops, even if outlets aren't closed.

The flow of granules from most applicators is basically caused by gravity. Operating at field speeds different than those used in calibrating will cause variations in the application rate. Keep in mind that wind can greatly affect the distribution of granules. Check banders often to see that the proper band width is maintained; small height changes due to changing soil conditions result in significant changes in band width.

Clean the equipment thoroughly at the end of each job. Remove corrosion on the feeder plates or agitator with a wire brush, a file, or sandpaper. Be sure that all nuts and bolts are securely tightened. Lubricate the equipment in accordance with the manufacturer's specifications.



DUSTERS

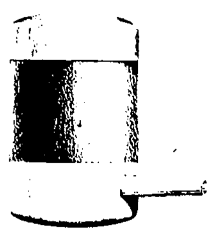
Dusters are used to a limited extent in Minnesota for the application of fungicides and insecticides. It is often more difficult to achieve uniform and complete coverage with dusts; they are easily washed from treated surfaces by rain; and they are highly susceptible to drift.

A duster normally consists of a hopper for the pesticide and a mechanism for producing a current of air into which the dust is either fed or dropped by gravity; the air current propels the material to the target. The current of air is normally produced either by a piston moving in a cylinder, a fan, or a bellows mechanism. The hopper usually contains an agitator which provides efficient and continuous feeding into the air current.

Dusters range from relatively simple hand units to fairly sophisticated power equipment. A hand duster may be simply a squeeze tube or shaker, a unit with a sliding tube, or a backpack unit consisting of a paddle-type fan powered by a hand crank. They are designed principally for home and garden use and for spot treatments.

Power dusters range from backpack units to large units which are either tractor-mounted or pulled. The duster may be driven either from the power take-off of the tractor or by an independent engine; those with independent engines are usually more satisfactory because their rate of delivery is not dependent on the speed of travel. With some units, the dust may be delivered through nozzles attached to a boom. Some power units are designed to apply either dusts or granules and others to apply either dusts or sprays. Power dusters are usually simply constructed and relatively easy and inexpensive to maintain and operate.

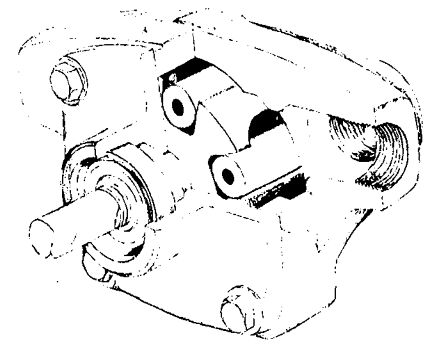
In selecting a power duster, choose a unit that is easy to clean and provides uniform distribution and a uniform application rate as the hopper is emptied. Where possible, select a unit which keeps the dust cloud well away from the operator.



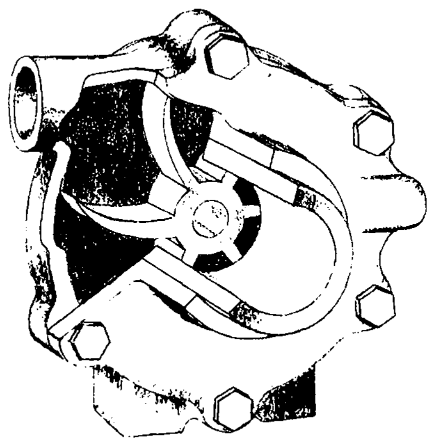
THE PUMP

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

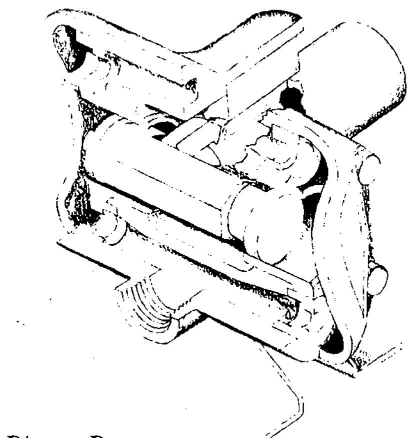
The pump must supply the solution to the distribution system under pressure and at a reasonably even flow. Its capacity must be sufficient to supply the nozzles and agitator, plus a slight excess to operate the relief valve. It is wise to select the pump slightly oversize to allow for some loss of efficiency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



Roller Pump



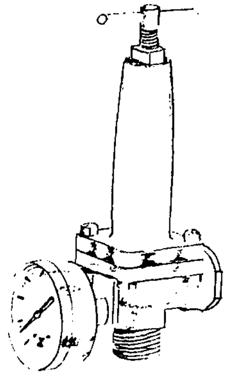
Centrifugal Pump



Piston Pump

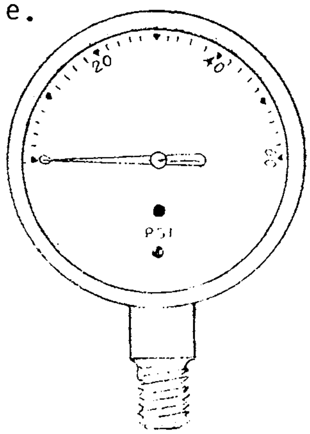
THE PRESSURE REGULATOR

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



THE PRESSURE GAUGE

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

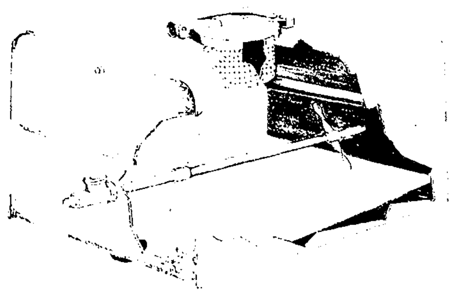


AGITATION

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

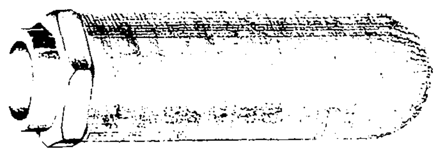
Jet agitators use liquid from the sprayer's pressure system. The line to the agitator should be connected between the pump and any cutoff valves to the nozzles so agitation will continue when spraying is stopped for turning or other momentary delays. The amount of liquid required for agitation depends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

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



STRAINERS

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



NOZZLES

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

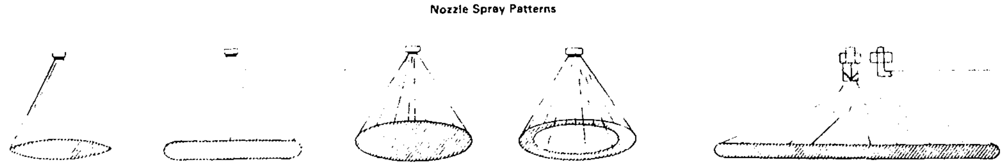
The flat spray nozzle produces a rather coarse spray in a fan-shaped pattern. It produces even coverage when overlapped with other nozzles in boom sprayer applications. It is suitable for most field weed control and some insect control where penetration of the foliage is not necessary. A wide angle nozzle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

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

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

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

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



NEW DEVELOPMENTS

New equipment and techniques are continually being developed in an effort to maximize the efficiency and safety of pesticide applications. We have already noted that many problems of current concern such as drift, nonuniform coverage, failure of a pesticide to effectively reach the target organism, and selective control are at least partially solvable through the development of new application techniques and equipment.

A number of significant developments have occurred in recent years and, while we don't expect that they will immediately revolutionize application practices, some of them may play increasingly important roles in the coming years.

NEW HERBICIDE APPLICATION TECHNIQUES

A number of new techniques, based on similar principles and designed for similar purposes, have recently been developed for herbicide applications. The new techniques are designed t o provide selective, post-emergence control of problem weeds which either escaped or were not susceptible to previous control methods; and they are designed to provide effective control at relatively low application rates.

These techniques are effective only if the problem weeds are significantly taller than the crop at some time during the growing season. They achieve maximum effectiveness against the widest spectrum of weeds if used with a systemic, nonselective herbicide which is effective at low dosages. Indeed, it was the introduction of Roundup, which meets these requirements, that was largely responsible for the development of these application techniques. Roundup controls both grasses and broadleafs and it translocates downward in the plant; wetting a small part of the top of a weed is often enough to kill the entire plant.

Some problems have been encountered, however, in using these techniques for the control of certain broadleafs, particularly velvetleaf and milkweed. In general, broadleafs are less susceptible than grasses to Roundup; the relatively low dosages applied using these methods have sometimes been insufficient to provide effective control

Recirculating sprayers (RCS) were the first to be developed. There are two basic types of recirculating sprayers, the box-type and broadcast.

With the **box-type sprayer**, three or four streams of herbicide are directed parallel to the ground above the crop canopy; the streams are aimed across the row into a catch basin. All spray that is not intercepted by weeds is pumped from the catch basin either back to the spray tank or directly back to the nozzles. Box-type sprayers may be rear or front-mounted on tractors or mounted on high-clearance equipment. Splashing may cause problems on sensitive crops.

Broadcast or **trough-type sprayers** were first sold under the trade name, Spray Sickle, but are now being manufactured by a number of companies. These sprayers are front-mounted, either on tractors or high-clearance equipment. They consist of a series of nozzles pointing backward toward a common trough or catch basin positioned above the crop canopy; they are used in broadcast fashion much like standard spray equipment. Unused spray is pumped from the trough to the spray tank from several points along the trough. The trough-type sprayer is more versatile than the box-type, but again, splashing may cause problems on sensitive crops.

Another type of broadcast sprayer, the **swabbing broadcast recirculating sprayer,** uses canvas stretched across the front of a recovery trough. The herbicide is sprayed forward onto the canvas and "wipes" on the weeds. The advantage of this unit is that the spray is totally enclosed (a plexiglass top allows viewing of nozzles) and is not affected by wind. The nozzles and recovery trough are also protected from trash.

The **roller applicator** is a somewhat different type of unit in which herbicide solution is trickled onto a carpet-covered roller that turns as the equipment is driven across the field; the herbicide is "wiped" onto weeds that contact the roller. The roller or drum measures 8-10 inches in diameter and rotates at about 50 rpm. The herbicide solution is applied manually to the carpet either through a drip boom or through low-pressure nozzles. A wiper constructed of belting runs against the drum and evens the solutions out on the carpet. Roller applicators should virtually eliminate drift and splash, but if the roller becomes too wet, the herbicide may drip onto the crop and cause damage.

The latest development is the **rope-wick applicator** which is essentially the same as the roller except that it doesn't rotate. It consists of a section of PVC pipe (usually 3-4 inches in diameter), with pieces of soft rope arranged in an overlapping pattern. The rope should provide a constant, high wicking rate and should be chosen carefully. A recent study conducted by the Monsanto Corporation and the Nebraska Agricultural Experiment Station found that a rope with a diamond-braided polyester covering and an acrylic yarn core (Gulf Rope and Cordage Co., "Pistachio") had the highest wicking rate of those tested. The herbicide solution is placed inside the pipe and the pieces of rope become wet through wick action. The applicator drips very little or only occasionally. When treating dense stands, however, treated weed stems may contact crop leaves and cause severe injury. A rope-wick appicator is relatively easy and inexpensive to build and uses only a small amount of herbicide.

These selective applicators are not the answer to all of our weed problems, but they do provide excellent and economic control for many tall, problem weeds. Keep in mind, however, that the application can be made only after weeds have grown significantly taller than the crop; by this time most crop loss from competition may already have occurred and driving through the field this late in the season may be impractical. Use of these techniques should not be considered as primary weed control practices but only as supplementary methods where regular cultural and chemical control measures have failed.

At the present time, Roundup is the only herbicide registered for use with these applicators, although other translocated herbicides are being tested.

CONTROLLED DROPLET APPLICATORS

Although the standard hydraulic spray nozzle has proven effective over the years, it does have significant drawbacks. It relies on pressure to break the spray solution into droplets and, in so doing, produces an extremely wide range of droplet sizes. The smaller droplets are highly succeptible to drift and the larger ones provide inefficient coverage and are subject to runoff from treated plant surfaces. Although hydraulic nozzles normally produce a relatively small percentage of large drops, they may contain the greatest amount of spray volume.

The diameter of spray droplets is measured in microns; a micron is 1/1000 of a millimeter (approximately 0.0004 inches). It has been shown that drops smaller than 50 microns are highly susceptible to drift under normal conditions and that the ideal range for general spray applications is from 80-150 microns.

Substantial research has been directed toward the development of nozzles which produce a majority of droplets in this general size range. The most promising are nozzles which use spinning disks, cups, or screens. The controlled droplet applicators (CDA's) used most widely today are manufactured by Micron Sprayers and are commonly referred to as rotary spray nozzles. They use a spinning cup which has small grooves extending radially up the inner wall. The nozzles are gravity-fed from the spray tank and are powered by small electric motors. The spray solution initially forms a pool at the bottom of the spinning cup. It is then moved up the grooves on the inside of the cup by centrifugal force and, when it reaches the edge of the cup, is distributed in a hollow-cone pattern. When they leave the cup, the spray droplets are flung out parallel to the ground and then fall almost vertically onto the crop.

Rotary spray nozzles generate relatively uniform droplets, with the average size ranging from 40 to 250 microns depending on cup diameter, speed, and flow rates.

Tests have indicated that rotary nozzles can provide equivalent control with less volume of spray solution and less drift. The pesticide is applied in three gallons of solution or less per acre. This obviously results in substantial reductions in water use and in fuel consumption and would permit the use of smaller and lighter spray equipment. There have also been claims that more efficient coverage and reduced spray drift would allow significant reductions in the amount of pesticide applied; the evidence to date, however, is not conclusive. It should be pointed out that, since rotary nozzles do not apply the spray under pressure, canopy penetration in crops such as soybeans may not be satisfactory. A substantial amount of additional research needs to be done before we can make a judgement on the potential value of these applicators.

While one the the principal advantages of rotary nozzles is the use of less spray volume, keep in mind that you cannot use a volume less than that specified on the label unless it is based on an appropriate recommendation (see chapter on "Pesticide Laws and Regulations").

MONITORS AND GUIDANCE SYSTEMS

Applicators have shown considerable interest in using modern electronic systems to improve application efficiency. As a result, several companies have developed monitors that sense travel speed and total flow to the boom. The operator then inputs his swath width, and the monitor continuously displays the spray rate being applied. Some units can also display the nozzle flow, travel speed, area covered, total volume sprayed, and amount remaining in the tank. Another system is available that maintains a constant application volume regardless of travel speed. There are also monitors that indicate when a nozzle has clogged.

For swathing, the commercially-available Ag-Nav system uses radio signals that an onboard processor converts to a series of relative locations for the sprayer. A dashboard display then indicates whether the sprayer is on the selected swath or to the left or right of it.

RESPIRATORY PROTECTIVE DEVICES

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

CHEMICAL CARTRIDGE RESPIRATORS

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

CHEMICAL CANISTER RESPIRATORS OR GAS MASKS

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

CARE AND MAINTENANCE

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

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

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

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

RESPIRATORY PROTECTION FOR AGRICULTURAL WORKERS

Airborne contaminants are present in many agricultural work situations throughout the entire year. This includes such contaminants as nuisance dust, mold, toxic gases, pesticides, and ammonia used for plant food. Each requires certain safe procedures and protective equipment to reduce exposure to the worker.

In addition there are times, especially when working in an enclosed area such as a silo or a grain bin, that there may be insufficient oxygen present in the atmosphere. Under these situations oxygen must be supplied by means of a self-contained breathing apparatus or positive air supply system before a worker goes into the area.

Protective equipment can be obtained from farm supply stores and safety equipment companies primarily located in larger cities in the state. When purchasing protective equipment make sure it has NIOSH/MSHA identification. This seal tells the purchaser the item has been tested to provide protection against the listed contaminants.

This information relates **only** to respiratory protective equipment to protect against airborne contaminants. Other types of protective equipment for the eyes, ears, skin, head, feet, hands, and other parts of the body are available and should be used as situations demand.

It is realized that it is impractical for most farmers to purchase and use a self-contained breathing apparatus or a positive pressure air system in those sections where they are recommended. But, a farm worker should not enter these areas unless forced ventilation has been provided for at least one hour prior to entry and continues to circulate while the worker is in the area. It is of extreme risk for a worker to be in these areas without taking these precautions.

Mold (Farmers Lung Disease)

Farmers lung disease is one of the most common and disabling diseases, particularly among dairy and grain farmers. The fungus that causes the disease thrives in moldy hay, silage or grain. Mold is inhaled into the body and triggers an allergic reaction. They symptoms are often mistaken for bronchitis or pneumonia. If notr diagnosed early, it can move into an irreversible stage permanently damaging the lungs. The best protection for the farmer is to wear a dust respirator or air hat.

Work Situation: Handling moldy hay silage or grain

Contaminant: Mold fungi

Effects and Prominent Symptoms: Trouble breathing, fever, chills, nausea

Example of Protective Equipment Needed	Features	Approximate Cost
Dust respirator with two bands (Example 1)	Lightweight, economical, disposable, no maintenance	$.90-$1.00
Dust respirator with adjustable straps (Example 2)	Shaped to provide a positive seal, can be used a longer number of work hours	$3.50
1/2 face chemical cartridge respirator with dust filter and filter retainer. Read and follow instructions (Example 3)	Replacement filter is economical, filter must have chemical respirator to utilize	$21.00 respirator $.37 dust filter
Air hat. Read and follow instructions (Example 4)	Mobile, lightweight provides protection for head, face and lungs, operator can wear up to 10 hours before recharging battery	$400.00
Powered, positive pressure hooded respirator (not shown)	Mobile, lightweight, multi-powered by portable battery, car battery or A.C., protects lungs, eyes, hair, ears, and face	$190.00

Protection from Nuisance Dust

Dust particles in the air of 5 microns or less can be trapped in the lungs. These particles must be filtered out by mechanical means such as a dust respirator--if you must work in this environment. Particles over 5 microns can usually be expelled form the trachea and bronchus. (1 micron equals 1/25,000 of an inch.)

Work Situation: Cleaning out grain bins, handling animal feed and bedding, dusty field conditions, sweeping barn floors.

Contaminant: Nuisance dust.

Effects and Prominent Symptoms: May aggravate existing lung conditions and often long periods of exposure can cause lung problems such as bronchitis and emphysema.

Example of Protective Equipment Needed	Features	Approximate Cost
Disposable dust respirator must fit properly around nose and mouth (Example 1)	Lightweight, economical, disposable, no maintenance	$.90 - $1.00
Dust respirator with adjustable straps (Example 2)	Shaped to provide a positive seal, can be used longer number of work hours	$3.50
1/2 face chemical cartridge respirator with dust filter and filter retainer. Read and follow instructions (Example 3)	Replacement filter is economical, filter is efficient, disposable. Must have chemical respirator to utilize.	$21.00 respirator $.37 dust filter
Air hat system Read and follow instructions (Example 4)	Mobile, lightweight provides protection for head, face, and lungs, battery operates for about 10 hours before recharge.	$400.00
Power, positive pressure hooded respirator	Mobile, lightweight, multi-powered by portable battery, car battery or A.C., protects lungs, eyes, ears, hair, and face.	$190.00

Pesticides

Inhalation of pesticide vapors is considered the most toxic way for pesticides to enter the body. This is because the inhaled particles are absorbed rapidly into the circulatory system through the thin membranes of the lungs. Inhalation of pesticides can be reduced by wearing a chemical respirator with the correct cartridge or canister. It contains material (activated charcoal) which removes the organic vapors from the air produced by the pesticide. In addition to the activated charcoal the cartridge can be equipped with a dust and mist filter.

Work Situation: Diluting or mixing concentrates, spraying animals, or dusting animals.

Contaminant: Pesticides vapors.

Effects and Prominent Symptoms: Varies with specific pesticide but may cause lung damage ond poisoning.

Example of Protective Equipment Needed	Features	Approximate Cost
1/2 face chemical cartridge respirator with pesticide cartridge. Read and follow instructions. (Example 5)	Interchangeable filters and cartridges to fit a range of respiratory hazards.	$21.00
Full face chemical cartridge respirator with pesticide cartridge. Read and follow instructions. (Example 6)	Same as above but also provides eye and face protection.	$100.00
Full face chemical gas mask with pesticide canister. Read and follow instructions. (Example 7)	Canister provides protection at higher levels of contaminants and for a longer duration than a chemical cartridge.	$175.00

Ammonia

Ammonia (NH_3) has a sharp, pungent odor that alerts a worker to its presense at low levels (50 ppm). It causes irritation of the respiratory tract at medium levels (400 to 700 ppm), and asphyxiation at high concentration. At low levels a chemical cartridge respirator can be worn for a short period of time or until the gas is detected by smell. A gas mask with an ammonia canister can be used at slightly higher concentrations of ammonia for a longer period of time. In areas of high concentration of ammonia (2,000 ppm and higher), a self-contained breathing apparatus must be worn along with a slicker or protection suit to cover the rest of the body.

Work Situation: Transferring anhydrous ammonia to nurse tank or from nurse to applicator.

Contaminant: Ammonia (NH_3) gas

Effects and Prominent Symptoms: Irritation of the respiratory tract and asphyxiation at high levels.

Example of Protective Equipment Needed	Features	Approximate Cost
1/2 face chemical cartridge respiratory with ammonia cartridge. Read and follow instructions. (Example 5)	Interchangeable filters and cartridges to fit a range of respiratory hazards	$21.00
Full face chemical cartridge respirator with ammonia cartridge. Read and follow instructions. (Example 6)	Same as above but also provides eye and face protection.	$100.00

Work Situation: Minor NH_3 leak on portable or stationary supply tank.

Contaminant: Ammonia NH_3 gas.

Effects and Prominent Symptoms: Irritation of the respiratory tract and asphyxiation at high levels.

Example of Protective Equipment Needed	Features	Approximate Cost
Ammonia gas mask with ammonia canister. Read and follow instructions. (Example 7)	Canister provides protection at high levels of contaminants and for a longer duration than the chemical cartridge.	$175.00

Work Situation: Major NH_3 leak causing high concentrations of NH_3 from ruptured tank or overturned tank.

Contaminant: Ammonia NH_3 gas.

Effects and Prominent Symptoms: Irritation of the respiratory tract and asphyxiation at high levels.

Example of Protective Equipment Needed	Features	Approximate Cost
Self-contained breathing apparatus, must be trained to use. (Example 8)	Lightweight 30 to 60 min. duration, provides positive pressure air supply.	$1,500.00

Insufficient Oxygen

Atmospheres where the level of oxygen is lower than 19.5 percent can cause drowsiness and asphyxiation. Carbon dioxide and most toxic gases are heavier than air and therefore may replace the air normally present in a confined area such as a grain bin, silo, or manure pit. A self-contained breathing apparatus will provide air to breath for 30 to 60 minutes depending upon the model used. A positive pressure air supply system with emergency escape cylinder can also be used in these situations.

Work Situation: Entering grain bin where high moisture grain has fermented, or a manure pit during or after agitation, or combustion present from an engine exhaust in a garage or workshop, or inadequate ventilation or ventilation failure in livestock confinement area, or sealed silos or oxygen limiting silos.

Contaminant: Carbon dioxide (CO_2) or unknown gas(s).

Effects and Prominent Symptoms: Trouble breathing, headaches, drowsiness, and asphyxiation.

Example of Protective Equipment Needed	Features	Approximate Cost
Self-contained breathing apparatus, must be trained to use. (Example 8)	Lightweight 30 - 60 min. duration, provides positive pressure air supply.	$1,500.00
Positive pressure air supply system with emergency escape cylinder. (Example 9)	250 feet of air hose includes small 5 min. cylinder for emergency escape, lightweight, provides easy access through restricted areas.	$1,000.00

Toxic Gases

Toxic gases are produced by fermentation of silage in a silo and decomposing manure in a pit or lagoon. If you must work in an area where toxic gases are present, protect yourself by wearing a self-contained breathing appartus or a positive pressure air system. Dust masks and chemical respirators do not provide protection in this type of atmosphere. A self-contained breathing apparatus will provide air to breath from 30 to 60 minutes. A positive pressure air supply system with emergency escape cylinder may also be used in a toxic gas situation.

Work Situation: Near or in silo or silo chute room. Working in barn while agitating manure slurry in pit and ventilation failure or inadequate ventilation.

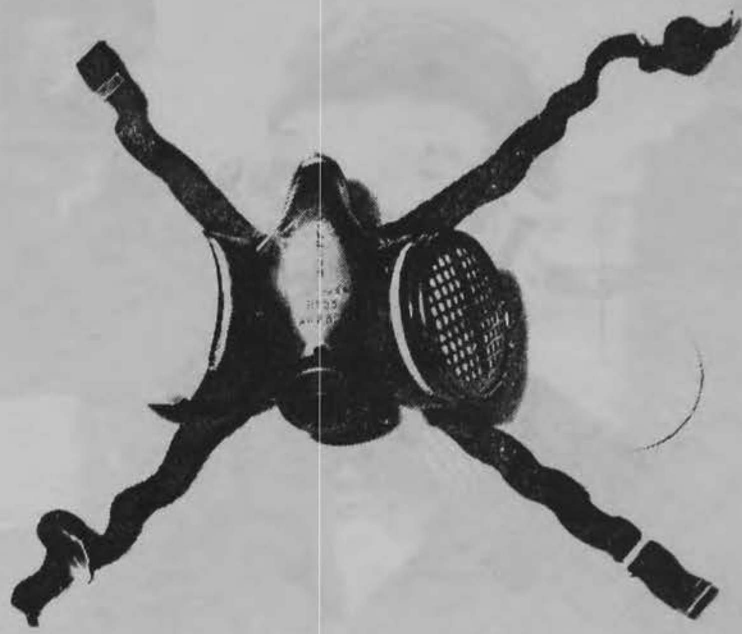
Contaminant: Nitrogen dioxide (NO_2) dangerous levels present for up to three weeks after filling. Hydrogen sulfide (H_2S) or ammonia (NH_3).

Effects and Prominent Symptoms: Irritation of eyes and mucous membrane, silo fillers disease shortness of breath, fever, dizziness, nausea, unconciousness, and death.

Example of Protective Equipment Needed	Features	Approximate Cost
Self-contained breathing apparatus, must be trained to use. (Example 5)	Lightweight, 30 - 60 min. duration, provides positive pressure air supply.	$1,500.00
Positive pressure air system with emergency escape cylinder. (Example 9)	250 feet of air hose, includes small 5 min. cylinder air supply for emergency escape	$1,000.00

Example 1

Example 2



Example 3

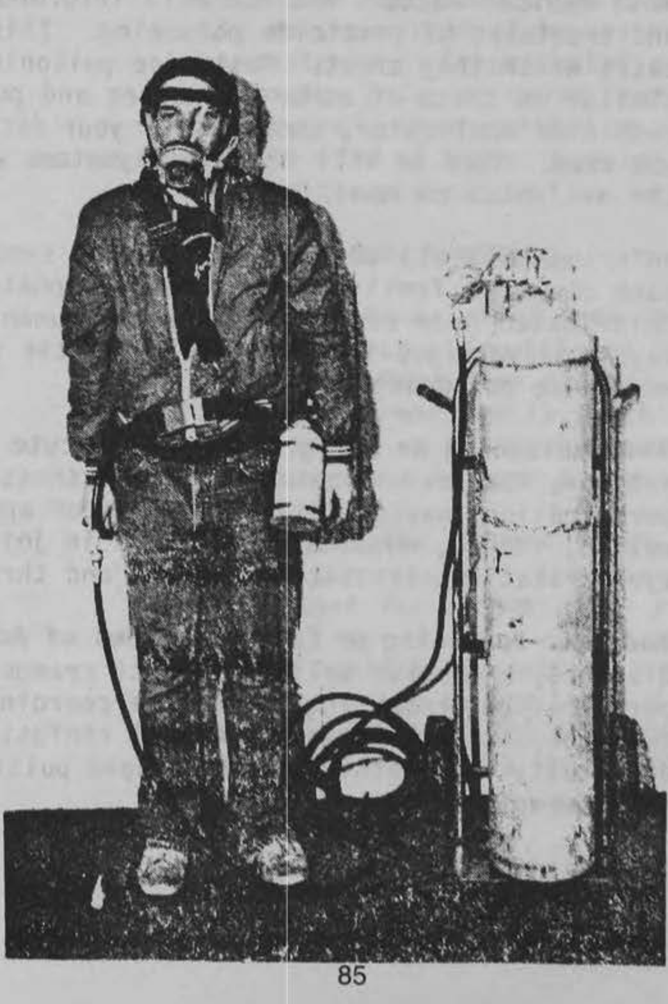
Example 4

Example 5

Example 6

Example 7

Example 8



Example 9

SYMPTOMS OF PESTICIDE POISONING

PESTICIDE POISONING OR NOT?

The symptoms of pesticide poisoning are similar to those of other types of poisoning and of other diseases. Heat exhaustion, food poisoning, asthma, and other illnesses are sometimes confused with pesticide poisoning. Just because a person becomes ill after using or being around pesticides is not proof that he is poisoned.

The symptoms of poisoning described here may occur in a person who has been suddenly exposed to large quantities of a toxic material. or they may occur in a person who has been continuously exposed to smaller quantities of toxic material over longer periods of time. If the symptoms appear call your doctor and tell him what pesticide was involved.

KINDS OF POISONING

Acute poisoning is the severe poisoning which occurs after exposure to a single dose of pesticide. The appearance of symptoms may be sudden and dramatic or may be delayed.

Chronic poisoning is the poisoning which occurs as a result of repeated, small, nonlethal doses over a long period of time. Many symptoms may appear, such as nervousness, slowed reflexes irritability, or a general decline of health. Some test animals are unable to reproduce normally after repeated exposure to pesticides.

Most medical doctors are not well informed as to the symptoms and treatment of pesticide poisoning. This is due to the few cases which they treat. Pesticide poisoning symptoms are similar to those of other illnesses and poisonings. You, the pesticide applicator, should tell your doctor which chemicals you used. Then he will know the symptoms and treatment and have the antidotes on hand.

GENERAL SYMPTOMS

Unfortunately all pesticide poisoning symptoms are not the same. Each chemical family, i.e., organophosphates, carbamates, chlorinated hydorcarbons, attack the human body i a different way. However, you should be aware of the general symptoms of pesticide poisoning.

Mild Poisoning or Early Symptoms of Acute Poisoning--headache, fatigue, weakness, dizziness, restlessness, nervousness, perspiration, nausea, diarrhea, loss of appetite, loss of weight, thirst, moodiness, soreness in joints, skin irritation, eye irritation, irritation of nose and throat.

Moderate Poisoning or Early Symptoms of Acute Poisoning--nausea, diarrhea, excessive saliva, stomach cramps, excessive perspiration, trembling, no muscle coordination, muscle twitches, extreme weakness, mental confusion, blurred vision, difficulty in breathing, cough, rapid pulse, flushed or yellow skin, weeping.

Severe or Acute Poisoning--fever, intense thirst, increased rate of breathing, vomiting, uncontrollable muscle twitches, pinpoint pupils, convulsions, inability to breathe, unconsciousness.

To Vomit or Not to Vomit (should you make the victim vomit?)

The most important choice you have to make when aiding a person who has swallowed a pesticide is to vomit or not to vomit. The decision must be made quickly and accurately; the victim's life may depend on it. Usually it is best to get rid of the swallowed poison fast...But:

- Never induce vomiting if the victim is unconscious or is in convulsions. The victim could choke to death on the vomitus.

- Never induce vomiting if the victim has swallowed a corrosive poison. Find out what poison the person has ingested. A corrosive poison is a strong acid or alkali such as dinoseb. The victim will complain of severe pain and have signs of severe mouth and throat burns. A corrosive poison will burn the throat and mouth as severely coming up as it did going down.

- Never induce vomiting if the person has swallowed petroleum products (that is kerosene, gasoline, oil, lighter fluid). Most pesticides which come in liquid formulations are dissolved in petroleum products. The words "emulsifiable concentrate" or "solution" on the pesticide label are signals **NOT** to induce vomiting in the poison victim if he has swallowed the concentrates. Concentrated petroleum products (lkike corrosive poisons) cause severe burns. They will burn as severely when vomited up. If he has swallowed a dilute form of these formulations, he should be forced to vomit immediately.

How to Induce Vomiting

Do not waste a lot of time inducing vomiting. Use it only as first aid until you can get the victim to a hospital. Make sure the victim is lying face down or kneeling forward while retching or vomiting. Do not let him lie on his back because vomitus could enter the lungs and do more damage.

- First give the patient large amounts of milk or water. One to two cups for victims up to five years old; up to a quart for victims five years and older.

- Induce vomiting by putting your finger or the blunt end of a spoon at the back of his throat. Do not use anything which is sharp or pointed! A glass of soapy water or strong salt water will also cause the victim to vomit.

- Collect some of the vomitus for the doctor; he may need it for chemical tests.

The best first aid is to dilute the poison as quickly as possible and to neutralize the acid or alkali causing the burns. It is very important that the victim get to a hospital without delay.

- For acids or alkali (base) give patient water or preferably milk. One to two cups for victims under five years; up to a quart for patients over five years. Milk is better than water because it dilutes and helps neutralize the poison. Water only dilutes the poison.

- For Acids only. If you are sure that the poison is an acid give the patient milk of magnesia (one tablespoon to one cup of water), baking soda, or chalk in water.

- For Alkali only. If you are sure that the poison is an alkali give the patient lemon juice or vinegar.

"UNIVERSAL SPONGE"

Use these "sponges" to absorb excess poisons only after first aid suggestions for the Corrosive or Noncorrosive poisons are followed.

Activated Charcoal--it absorbs many poisons at a high rate. Mix it with water into a thick soup for the victim to drink. Activated charcoal is found in aquarium filters or is available from a drug store.*

Homemade Absorber--a homemade "universal" sponge for poison is a mixture of four tablespoons of toast (burnt black), two tablespoons of strong tea (instant ice tea mix will do), and two tablespoons of milk of magnesia. This is used to absorb and/or neutralize most poisons.

ATROPINE

Atropine tablets should not be taken in a poisoning emergency, the dose is much too small. Often the victim cannot or should not take oral medicine. The atropine can hide or delay early symptoms of poisoning. The victim may be fooled into thinking he is okay and may even go back to work. Or a doctor may not detect the problem because the symptoms are hidden by the atropine.

WARNING: Atropine can be poisonous if misused. It should never be used to prevent poisoning. Workers should not carry atropine for first aid purposes. It should be given only uinder doctor's directions.

CALL A DOCTOR

First Aid is just that. It is the initial effort to help a victim while medical help is on the way. Step one in any poisoning emergency is to call an ambulance or doctor. The only exception is when you are all alone with the victim. Then you must see that he is breathing and that he is not further exposed before leaving him to make you phone call. Always save the pesticide nd the label for the doctor.

WHILE WAITING TO DO THIS FOR:

POISON ON THE SKIN

- The faster the poison is washed off the patient, the less injury will result.
- Drench skin and clothing with water (shower, hose, faucet, pond).
- Remove clothing
- Cleanse skin and hair thoroughly with soap and water. Detergents and commercial cleansers are better than soap.
- Dry and wrap in blanket.
- WARNING: Do not allow any pesticide to get on you while you are helping the victim.

CHEMICAL BURNS OF THE SKIN

- Wash with large quantities of running water.
- Remove contaminated clothing.
- Immediately cover loosely with a clean, soft cloth.
- Avoid use of ointments, greases, powders, and other drugs in first aid treatment of burns.

POISON IN THE EYE

- It is most important to wash the eye out as quickly but as gently as possible.
- Hold eyelids open, wash eyes with a gentle stream of clean running water.
- Continue washing for 15 minutes or more.
- Do not use chemicals or drugs in wash water. They may increase the extent of the injury.

INHALED POISONS (DUSTS, VAPORS, GASES)

- If victim is in an enclosed space, do not go in after him without an air-supplied respirator.
- Carry patient (do not let him walk) to fresh air immediately.
- Open all doors and windows.
- Loosen all tight clothing.

- Apply artificial respiration if breathing has stopped or is irregular.

- Keep patient as quiet as possible.

- If patient is convulsing watch his breathing and protect him from falling and striking his head. Keep his chin up so his air passage will remain free for breathing.

- Prevent chilling (wrap patient in blankets but don't overheat).

- Do not give alcohol in any form.

SYMPTOMS OF SHOCK

Sometimes poisoning victims go into shock. If untreated or ignored the victim can die from shock even if the poisoning injuries would not be fatal.

The skin will be pale, moist, cold and clammy. The eyes are vacant and lackluster with dilated pupils. The breathing will be shallow and irregular. The pulse is very weak, rapid and irregular. The victim may be unconscious or in a faint.

- Unless he is vomiting, keep the victim flat on his back with his legs up 1-1/2 feet above his head.

- Keep the victim warm enough to prevent shivering. Do not overheat.

- If the victim is conscious and has not swallowed any poison, gie small amounts of water or a dilute salt solution (1/2 teaspoon of table salt to 1 quart of water). Give as often as the victim will accept it.

- Keep the victim quiet and reassure him often.

WARNING

- Never try to give anything by mouth to an unconscious victim.

- In an emergency use any source of fairly clean water such as irrigation canals, lakes, ponds, watering troughs, etc. Don't let the victim die while you worry about how dirty the water is.

POISON CONTROL CENTERS

Poison Control Centers have been established to give pertinent information on all types of poisonings including pesticide poisoning. The applicator should have posted near his phone the telephone number of the nearest Poison Control Center, and his doctor should also have the number available.

In any poisoning emergency, think first of water. Your first aim is to dilute the pesticide no matter where it is. Then get the victim to a doctor fast.

FIRST AID KIT

A well equipped first-aid kit which is always readily available can be important in a pesticide emergency. Make up your own Pesticide First-Aid 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 won't come open or allow pesticides to leak inside. Label it clearly with paint or a water proof marker.

CONTENTS

1. A small plastic bottle of a common **Detergent.** It is used to wash pesticides quickly off the skin.

2. A small plastic container of **Salt.** Salt is used with water to induce vomiting or to aid a person in shock.

3. A box or plastic container of **Baking Soda** or a bottle of **Milk of Magnesia.** these mixed with water will neutralize acidic chemicals that have been swallowed.

4. A plastic bottle of **Lemon Juice** or **Vinegar.** these are used with water to neutralize basic or alkali chemicals which have been swallowed.

5. A small package or bag of **Activated Charcoal.** Mixed with water and swallowed, activated charcoal acts as an absorber of all pesticides.

6. **A Shaped Plastic Airway** for mouth-to-mouth resuscitation.

7. A thermos or large plastic bottle (at least one pint) of **Clean Water.** if there is no clean water in an emergency use any pond or stream water available.

8. Simple **Band Aids, Bandages** and **Tape.** All cuts and scrapes should be covered to prevent pesticides from easily entering the body.

9. A **Blanket** is very useful. It should be kept in a place where it will not be contaminated by pesticides.

10. A **Quarter** should be always taped to the inside cover of the first aid kit. It is for an emergency phone call.

11. A small, plastic **Empty Jar** with a tight fitting lid is useful as a drinking glass for the victim in order to induce vomiting or feed activated

charcoal. It can be used for collecting vomitus to take to the doctor.

12. A card with the doctor's, hospital's and Poison Control Center's telephone numbers on it. A pencill should also be included to record information on the time and duration of expousure, and what chemicals are involved (from the Pesticide Label).

13. Many people have health conditions that may be important for the doctor t know. This information may be kept on a card in the First Aid Kit.

A CHECKLIST FOR PREVENTING PESTICIDE ACCIDENTS

Everyone can improve their methods for safe handling of pesticides. Experienced pesticide applicators may become so familiar with the equipment and materials used that they become careless or take shortcuts. Then an accident can happen.

The following checklist of questions is drawn from data showing the common causes of pesticide accidents. Check it against your pesticide handling practices and see how many accidents are waiting to happen to you. Just one "No" may be the one that gets you in trouble!

Store Your Pesticides Safely

Do you have a separate space to store pesticides?

Do you keep it locked and are the windows tight, barred or boarded over?

Do you keep all your pesticides in this storage rather than in the garage, feed room, basement, porch, kitchen or refrigerator?

Do you store herbicides separately from other pesticides?

Are there signs on your storage so firemen and others are warned?

Do you check periodically for leaking containers?

Keep in the Original Container So the Label Is There!

Do you always keep pesticides in the original container instead of old "coke" bottles, milk cartons or other food continers?

When people ask you for a little spray mix out of your tank do you refust?

Do you always remember what is an unlabeled container?

Do you always remember the safety precautions, antidotes and directions for use, even though the container is not labeled?

Do you safely dispose of unlabeled pesticides, rather than take a chance with your memory?

Use the Recommended Clothing and Protective Equipment

Do you read the label to see what protective clothing you should wear?

Do you start each spraying day with clean spray clothing?

Do you check the signal words and precautions for use on the label to see what protective equipment is necessary?

Do you wear the protective equipment recommended on the label?

Do you clean and maintain your protective equipment regularly and often?

Do you throw away rubber gloves that have onlytiny holes in them?

Spills and Splashes of Concentrates can be Very Hazardous!

Do you know what to do if you should spill a pesticide on yourself while mixing?

Do you wear adequate footgear with your pant cuffs on the outside so pesticides won't run into your footgear?

Do you have sawdust, vermculite, kitty litter or some other absorbent on hand to soak up spills?

Do you always watch your sprayer tank when filling so it won't run over and spill on the ground?

Do you have a check valve or other device on your equipment to prevent back-siphoning into the water supply?

Is your application equipment well maintained soi it doesn't leak and leave toxic puddles or piles of pesticide on the ground?

Do you avoid draining leftover spray mix on the ground?

Do you discard old high pressure hose instead of patching it and hoping no one will be nearby when it bursts?

Do you clean nozzles with a brush, by rinsing, etc., instead of blowing them out with your mouth?

Poor Container Disposal May Cause Bad Accidents!

Do you rinse each "empty" liquid container at least three times and dump the rinsings into the tank?

Do you keep your used containers in your storage area until disposed?

Do you collect every container for disposal before leaving a job instead of leaving them in the field or at your tank filling station?

Do you puncture, break or crush nonburnable containers so they can't be reused?

Do you keep or return to the manufacturer 30 and 55 gallon pesticide drums, rather than giving them away for floats, trach barrels, etc.?

Attractive Nuisances Can Result in Lawsuits!

Do you keep your spray equipment where children cannot play on it?

Doyou keep your spray equipment clean so that those touching it will not be contaminated?

Do you always release pressure on your equipment so spray guns won't be accidentally triggered?

Care in Application Prevents Accidents

Do you check the wind direction and the area downwind before applying pesticides?

Do you consider substituting a safer chemical if you are spraying near a sensitive area?

Do you check for the possibility of showers and damaging runoff before applying pesticides?

Do you plan your pesticide application wo it will have little or no effect on bees, birds, fish or other wildlife?

Do you remove, turn over or cover up pet dishes, sand boxes, plastic pools, etc., before spraying a private property?

Do you make sure that children and pets are out of the area and stay out until the spray dries?

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

GLOVES

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

BODY COVERING

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

HAT

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

BOOTS

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

GOGGLES OR FACE SHIELD

Wear goggles or a face shield when there is a risk of pesticides coming in contact with your eyes. Your eyes will not only absorb many pesticides, but your vision may be affected. You can wear goggles separately or in combination with a respirator.

WASHING CLOTHING WORN WHILE APPLYING PESTICIDES

Clothing such as gloves, boots, long-sleeved shirts, trousers, jackets, coveralls, hats and aprons can provide some protection against pesticides entering the body through the skin. Neoprene or rubber-coated clothing will prevent penetration of pesticides into the body. Research shows that two layers of clothing provide more protection than a single layer. Smooth T-shirt fabric is recommended for the under layer rather than fleecy seatshirt or very open meshlike fabrics.

An outer layer of spunbonded olefin or fabric with a soil-repellent finish offers more protection than durable press or untreated fabrics. Spunbonded olefin is available in disposable garments. Soil-repellent finishes can ve applied by clothing manufacturers or by consumers. While soil-repellent finishes offer more protection, research has shown it is more difficult to remove pesticides from fabrics treated with such a finish. It is important, however, that any item of clothing which has pesticide on it be washed before it is worn again.

The following recommended practices for washing clothes worn while applying pesticides are based on current research conducted at several universities. The studies focused on a few pesticides and fabrics; generally, the more toxic pesticides and fabrics; generally, the more toxic pesticides were used.

HANDLING CLOTHING

If liquid concentrates are spilled on clothing other than rubber or neoprene gloves and unlined boots, the clothing should be discarded since washing will not remove enough pesticide to make it safe to wear. Wear rubber gloves when handling these items. Research showed clothing with "undiluted" emulsifiable concentrate on it still contained a high amount of pesticide even after ten washings. Three washings removed nearly all of the "diluted" pesticide.

Empty pesticide granules from cuffs and pockets outdoors. If left in clothing, granules will dissolve in the wash water and may not be removed from the clothing in the remainder of the wash cycle.

Keep items worn while applying pesticides separate from other clothing before washing. Wear rubber gloves when handling clothing with pesticides on it.

Wash clothing DAILY when applying pesticides. The longer the clothing is stored, the harder it is to remove pesticides.

WASHING PROCEDURES

Prerinse or presoak the clothing in a bucket or tub or by agitating in a washer and spinning out before the regular wash. Prerinsing followed by a regular wash has been found to be much more effective than washing alone in removing pesticides, especially wettable powders.

Use hot water for washing, never cold. Cold water (86 F or lower) removes much less pesticide than warm (120 F) or hot (140 F) water.

Wash a small number of items at a time, using the highest water level and longest wash time available on your machine.

Use the recommended amount of heavy-duty detergent. Liquid detergents are more effective than powdered detergents on oil-based pesticides, which are generally the most difficult to remove.

Neither bleach nor ammonia contribute to pesticide removal. Either may be used for other reasons in laundering. NEVER use them together because poisonous gases are produced.

LAUNDRY EQUIPMENT CARE

Line dry when possible to avoid dryer contamination. Run the empty washing machine through a complete cycle with detergent after washing clothing worn while applying pesticides.

The hazard level of pesticide exposure depends on toxicity and pesticide formulation as well as the amount and type of exposure. Therefore, you should know:

- When and which pesticides are being used--so contaminated clothing can be handled and laundered appropriately.

- Toxicity Level of the pesticide as indicated by one of three signal words on the label.

- Product Formulation - A factor in ease of pesticide removal:

- EMULSIFIABLE CONCENTRATES (EC) are very difficult to remove from fabrics.

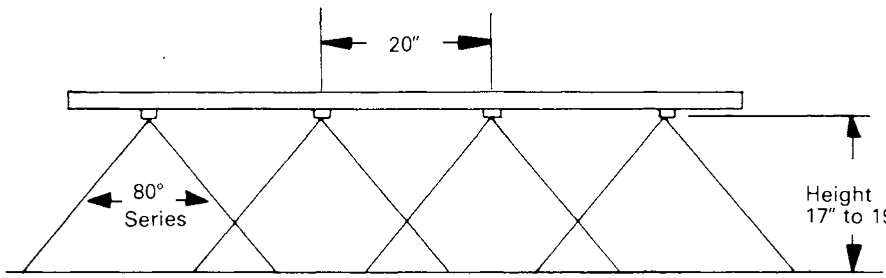
- WETTABLE POWDER (WP) formulations especially benefit from prerinsing.

Read the pesticide label and follow instructions as a final authority on pesticide use.

CALIBRATION

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

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



NOZZLE CAPACITY CHART

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

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

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

1. Determine the distance your spray must travel to cover 1 acre. Do this by dividing the spraying width (in feet) into 43,560 (the square feet in an acre).

2. Mark off this distance in the field or area to be sprayed. A fraction of this distance may be used to equal the same fractional part of an acre.

3. Prepare the sprayer and set the pressure where it will be used for spraying.

4. Select a ground speed that is safe and mark the throttle setting or note the speed so you can duplicate it later.

5. Fill the tank to a measurable mark with water.

6. Spray over the marked course. Be precise in turning the spray on and off at the start and end of the course. Maintain a uniform speed.

7. Measure the amount of water necessary to refill the tank. If the carrier used in spraying is to be an oil solution and you use water for calibration, add 10 percent to the volume measured. If your course covers a full acre, the amount necessary to refill is the GPA you are applying. If you chose a shorter course to represent a fraction of an acre, the refill amount will be the same fractional portion of the GPA.

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

USE OF TABLES

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

FORMULAS

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

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

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

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

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

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

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

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

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

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

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

To check ground speed:

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

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

Minutes to cover 1,000 square feet =

$$\frac{1.38 \times GPA}{GPH}$$

Minutes to cover 100 square feet =

$$\frac{0.138 \times GPA}{GPH}$$

GPH can be determined by collecting the liquied from the nozzle for 3 3/4 minutes. The number of cupfuls collected is equivalent to the GPH output of the sprayer.

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

1. Use only clean water.

2. Keep proper screens in place.

3. Never use a metal object for cleaning nozzles.

4. Flush a new sprayer before you use it.

5. Do not lock a pump solidly to a tractor.

6. Lubricate your pump properly. Fill it with antifreeze or light oil when it isn't in use.

7. Clean the sprayer thoroughly after each use when changing chemicals before storage. To remove 2,4-D and similar materials, follow this procedure.

    a. Remove and clean all screens and nozzles with kerosene.

    b. Pump kerosene or fuel oil through the sprayer. Rinse the tank with kerosene or fuel oil.

    c. Circulate a cleaning solution (1 pound detergent with 40 gallons of water) through the bypass for 30 minutes and flush part of it through the sprayer. Empty the remainder.

    d. Fill the tank with water and ammonia. Add 1 quart of household ammonia to 25 gallons of water. Pump enough solution through the hose and nozzles to fill these parts. Fill the tank, close it and leave it for 24 hours.

    e. Empty the sprayer and rinse it with water.

    f. The day before using the sprayer, fill the tank with clean water. Drain the sprayer before using it.

8. For extended storage periods, coat exposed metal parts with light oil to prevent rust.

Calibration of Granular Pesticides

Granular pesticides for weed or insect control are generally applied in a band over the row from applicators attched to the planter. A Successful Farming field study of 38 of these granular applicators showed nearly two-thirds significantly misapplied pesticides. Actual rates varied from an underapplication of 35 percent to an over-application of more than 90 percent.

There are a number of factors that can cause errors in the application rate of granular materials, but much like liquid materials, most result from poor calibration and worn equipment. Calibration of individual applicators is necessary for four reasons. First, settings recommended on the pesticide label are only meant to be a guide. Actual settings required to deliver the desired rate may differ. Second, all applicator units are not identical. Seemingly minor differences between units, even in new equipment, can substantially affect application rate. Third, wear can substantially increase application rates so recalibration is suggested every year. Finally, although pesticide granules may appear similar, each pesticide has different flow characteristics based on their size and bulk density. These flow characteristics can even change with granule moisture (high humidity or rain) and temperature. Thus, applicators must be recalibrated when changing between pesticides or when conditions change.

The small amount of time and effort that calibration requires often produces substantial benefits. Proper calibration avoids misapplication problems such as poor control or crop injury and frequently reduces pesticide cost.

Recommended granular application rates are generally given in pounds per acre or ounces per thousand row feet of formulated products. Herbicides and insecticide calibrations differ slightly. Herbicides are applied in a band at a constant rate per unit area so band with is critical to proper calibration. In contrast, insecticide applications vary in places. Band with is not considered in calibration so insecticides are applied at a constant rate pre length of row.

Calibration methods:

1. Set each applicator to the setting suggested in the equipment operators manual or on the pesticide label for the desired rate.

2. Fill the hoppers at least half full and run them until they all begin to feed.

3. Remove the feed tubes and attach a container, calibration bag or premarked calibration tube*.

4. Travel a measured course at planting speed, the longer the course the more accurate the calibration. Because ground speed and field conditions affect application rate, calibrate the planter in the worked field at the desired planting speed.

5. Weigh and record the amount of pesticide collected in each container using an accurate scale, such as a postage scale (remember to subtract empty container weight).

6. Calculate application rate for each row.

Formulae for insecticides:
Application rate (ounces per thousand row feet) =

$$\frac{1{,}000 \times (\text{ounces collected})}{\text{distance traveled (feet)}}$$

Application rate (pounds per acre) =

$$\frac{43560 \times \text{left (pounds collected)}}{\text{distance traveled (feet)} \times \text{row width (feet)}}$$

Formulae for herbicides:
Application rate (ounces per thousand row feet) =

$$\frac{1{,}000 \times (\text{ounces collected})}{\text{distance traveled (feet)} \times \text{band width (feet)}}$$

Application rate (pounds per acre) =

$$\frac{43560 \times \text{left (pounds collected)}}{\text{distance traveled (ft.)} \times \text{row width (ft.)} \times \text{band width (ft.)}}$$

If the application rate of any unit is not within 5% of the recommended rate, adjust the rate setting gauge and repeat the calibration.

A simple method of roughly checking application rates involves placing a vertical strip of tape within each hopper. Fill the hopper in one pound increments. After each pound is added, level the pesticide by shaking the hopper and mark the new level. Then, the application rate can be checked throughout the season by simply reading the pesticide levels before and after treating a known acreage.

MIXING AND LOADING PESTICIDES

Studies have shown that, of the normal activities associated with pesticide use, mixing and loading are the most hazardous. During these operations, a pesticide is handled in its most concentrated form and there is always the potential for significant exposure. All necessary precautions **must** be taken and proper procedures **must** be followed.

Be absolutely certain that you wear adequate protective clothing and equipment. Review the label **before** opening the container to be sure that you are thoroughly familiar with **current** use directions.

Choose a convenient outdoor location for pouring and mixing. If you must work indoors or at night, be sure there is good ventilation and sufficient light. A plentiful supply of clean water and detergent should always be available in the mixing and loading area. If at all possible, don't work alone.

Open pesticide containers carefully. Never tear open paper containers; use a sharp knife. Clean the knife afterwards and do not use it for other purposes.

When mixing and loading, always stand in the cross-wind, so that the wind blows across your body from either side; don't stand with the wind against your back or face.

When pouring a pesticide, keep the container well below eye level to minimize the risks of eye and face exposure. Where a concentrate has to be removed from a drum or other large container, this should always be done by means of a pump and/or threaded and valved piping. Always measure materials accurately; use only the amount specified on the label. Replace pour caps and close bags or other containers immediately and return them to the storage area. If a metal or plastic container has been emptied, triple rinse it and empty the rinsate into the spray tank; return the rinsed container to the storage area. Measuring cups sould also be rinsed and the rinsate emptied into the spray tank.

When adding water to a spray mixture, the hose or pipe should remain above the level of the mixture at all times to avoid the possibility of back-siphonage into the water source. It is safe to have an input line submerged in the mixture **only** when it is equipped with a reliable antisiphoning device. If an emulsifier or spreader-sticker is used, it should be added shortly before the tank is completely full, since these materials tend to cause foaming. Be extremely careful to avoid overflow. **Never leave a spray tank unattended while it is being filled.**

If you splash or spill a pesticide while mixing or loading--stop what you are doing immediately. Remove contaminated clothing and wash thoroughly with detergent and water. **Speed is essential.**

All mixing and loading equipment should be cleaned thoroughly after each use.

Never eat, drink, or smoke while handling pesticides.

CLEANING EQUIPMENT Immediately after use, all mixing, loading, and application equipment should be thoroughly cleaned by knowledgeable personnel. Cleaning should be done in a designated area, preferably on a wash rack and/or cement apron with a well-designed sump to catch all contaminated wash water for later disposal. When cleaning equipment, wear at least a long-sleeved shirt and long trousers or coveralls, unlined liquid-proof gloves and boots and an apron. Wear additional protective clothing and/or equipment as common sense dictates. Always keep in mind that pesticide residue on equipment can cause serious pesticide poisoning, particularly by absorption through the skin.

Residue may also cause either crop or livestock injury if it contaminates a different pesticide used in a subsequent application. This can be particularly important if herbicide residue is a contaminant in a later foliar application of another pesticde to a sensitive crop. For example, 2,4-D residue may severely injure soybeans treated with a post-emergence application of Basagran. In some instances, the solvent of the second pesticide may actually aid in loosening and removing residue. Remember that all equipment and equipment parts exposed to a pesticide will normally have some residue, including sprayer pumps, tanks, hoses, and boom ends. If significant quantities of different types of pesticides are applied, it is advisable to have one sprayer for herbicides only, and a second one for other pesticides.

Dirt and solid pesticide deposits trapped in strainers, screens, or other components can have a significant effect on sprayer output and, if dislodged during an application, may increase the application rate well beyond that determined in the calibration of the dirty sprayer.

The following are guidelines for cleaning spray equipment:

1. Drain all pesticide from the sprayer and flush it thoroughly with clean water.

2. Fill the sprayer to capacity with water, adding one cup of trisodium phosphate or household ammonia for each 10 gallons of water. If neither is available, use strong detergent or soap. Hormone-type herbicides (e.g. , 2,4-D; Banvel) can only be removed with ammonia.

3. Wash the tank and pump parts thoroughly by running the sprayer for about five minutes with the nozzles closed.

4. If possible, let the cleaning solution stand in the sprayer overnight. (Please note: household ammonia will corrode aluminum sprayer parts).

5. Discharge the liquid from the tank, spraying some through the nozzles.

STORAGE

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

All pesticides should be stored in their original containers with the labels intact in a secure place where children, unauthorized persons, and animals cannot enter. In most instances, this means in a locked storage room or cabinet. Never put pesticides in other containers like pop bottles, feed bags, or open buckets. Before storing any pesticide, read the label to see if any special precautions should be taken. then store the material Immediately in an appropriate storage facility. Most applicators use existing buildings, or areas within existing buildings, for pesticide storage. A pesticide storage facility should be located, if at all possible, downwind and downhill from sensitive areas such as houses, recreational areas, schools, or barns.

A pesticide storage facility should have a concrete floor which is impermeable and easy to wash; ideally, the structure should be fire-resistant. The storage area should be adequately lit and well-ventilated. You should never allow pesticides to become overheated and they should obviously not be stored close to any source of heat. Heat may cause liquid formulations to expand, thus increasing the chance of an accident when the containers are opened; some pesticide formulations may ignite if they become overheated.

Pesticides should also be adequately protected against freezing, especially those formulated as liquids. The components of some pesticide formulations may separate at low temperatures, making mixing difficult or impossible. Low temperatures may also cause rupturing of pesticide containers. The labels of most liquid products indicate the lowest temperature allowed for safe storage. Ideally, a storage facility should be well-insulated and should afford adequate protection against extremes in temperature.

If you are using an existing building for pesticide storage, the storage area should be located on the ground floor. It should be used only for pesticides and pesticide equipment; pesticides should never be stored with food, feed, seed, planting stock, fertilizers or veterinary supplies or with clothing, resirators or other protective equipment. Total decontamination of a pesticide storage facility is virtually impossible; the area should therefore, never be used subsequently for other purposes. Pesticide storage areas should always be kept locked when unattended.

Dry formulations packaged in sacks, fiber drums, boxes, or other water-permeable containers should be stored on wooden pallets or metal shelves. To avoid possible contamination from leaks, dry materials should not be stored on shelves below liquid formulations. If metal pesticide containers are to be stored for a prolonged period, they should also be placed on pallets or shelves to help reduce the potential corrosion. Defective containers should, if possible, be repaired; where this is not feasible, they must be disposed of in a proper manner. If a container is damaged, the contents may be transferred only to another container with an intact label which has held exactly the same product.

One of the best ways to reduce the potential for pesticide "incidents" is to buy only the quantity needed for immediate use. If circumstances make it necessary to maintain a larger inventory, older materials should be used first. containers should be tagged or marked with the date of purchase before being stored. The shelf-life of a pesticide is difficult to predict and manufacturers usually recommend that a product be stored for no more than two years; once a container is opened, the shelf-life is considerably reduced.

DISPOSAL OF EXCESS PESTICIDES AND CONTAINERS

There has been an increasing recognition in recent years that improper disposal of wastes can create serious hazards for both man and the environment. Perhaps the most highly publicized instance of improper disposal was that which occurred at Love Canal in New York State.

Although pesticides play a relatively minor role in the overall waste picture, the improper disposal of excess pesticides and containers can lead to serious problems. While there are not, as yet, easy solutions to all of the concerns facing applicators, adherence to a few basic guidelines can greatly reduce potential problems.

Laws governing waste disposal have been enacted on both the federal and state levels. The federal "hazardous" waste law is the Resource Conservation and Recovery Act (RCRA). Under RCRA some pesticide wastes are specifically identified as hazardous and must be handled and disposed of according to designated guidelines; you can obtain a list of these pesticides from your county extension office.

Although some pesticide wastes are designated by law as hazardous while others are not, this is simply a relative classificaiton. **All** pesticide wastes, be they RUP or not, must be handled and disposed of properly and in accordance with appropriate regulations. Unless otherwise indicated, the guidelines discussed below apply to all pesticides.

1. **Triple-rinse empty pesticide containers.** To triple-rinse, empty the pesticide into the spray tank and drain for a half-minute. Fill the container 10-20 percent full with water (or solvent in some cases) and rinse. Pour the rinsate into the tank and drain again for a half-minute. Repeat the rinsing procedure two more times. Puncture and flatten the can so it can't be reused.

   Putting rinsates into the spray tank closes the circle--rinsates are used in the spray itself, not haphazardly dumped on the ground. If you don't put rinsates into the spray tank, you must use them subsequently on a crop or other site listed on the label and in accordance with label directions; use them to mix future solutions of the same pesticide; or take them to an approved landfill.

   The rinse, pour, and drain routine can be tedious and time-consuming, especially during your busiest season; there are easier ways. An inexpensive jet-spray device is available which 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. Other alternatives may also be available.

2. **Safely dispose of rinsed containers.** Farmers can legally bury triple-rinsed containers on their own land. This must, however, be done conscientiously and with due regard

for appropriate precautions. In particular, be careful not to bury them near wetlands, streams, ponds or other surface waters. **Under no circumstances should rinsed containers be carelessly discarded.** It is virtually impossible to remove all toxic residue from a container.

Although legally permitted, many farmers prefer not to bury containers on their land. As an alternative, triple-rinsed containers can legally go to any approved landfill. There are hundreds of approved landfills across the state. Landfills have different burying schedules and some small landfills bury as seldom as once a month. Always check with the landfill operator for the best time to deliver containers.

Landfill operators, may have good reason to turn away pesticide containers. Containers aren't always triple-rinsed, as they should be. If unrinsed containers disposed of in the landfill cause environmental or health problems at any time, the operator is legally liable. Many landfill operators don't want to take chances.

Farmers and landfill operators need to talk in order to arrive at a workable solution. Cooperation is the key to practical, legal container disposal.

3. **Better yet, recycle empty containers.** Triple-rinsed containers can be recycled. A list of these dealers is available from your county extension office.

4. **Watch your residues and rinsates.** These include:

   - Solutions left after a spraying job.
   - Water from washing the outside of the sprayer.
   - Water from rinsing the spray tank.
   - Spray left in the boom and hoses.
   - Haulback solutions from a spraying job interrupted by weather, breakdown, etc.
   - Small quantities of material spilled during mixing.

All residues and rinsates should be collected and used on a crop or other site listed on the label, or used to mix future solutions of the same pesticide. To make solution collection practical, some applicators mix solutions, rinse tanks, and wash equipment on an asphalt or cement pad equipped with an above-ground tank to hold runoff.

Please note: Dilution will not solve a hazardous waste problem. Ten gallons of hazardous waste diluted with 90 gallons of water equals 100 gallons of hazardous waste. Likewise, mixing hazardous waste with nonhazardous waste makes the entire quantity hazardous.

SPILLS

Pesticide spills can pose serious threats to human health and cause significant environmental contamination. A thorough knowledge of the appropriate steps to take in the event of a spill will allow you to minimize the potential for adverse effects and may save you a great deal of money--a cleanup can be expensive if you have to pay someone to do it for you, particularly if a delayed response has caused extensive contamination. Be prepared ahead of time; in the event of a spill, you will need to respond promptly and in a proper manner.

A spill may be relatively minor, involving one or a few leaking containers, or of major proportions where a truck overturns spilling its cargo, or the contents of a fully loaded spray tank or container are suddenly released because of an accident or equipment malfunction.

All mixing and loading equipment should be cleaned thoroughly after each use. Regardless of the magnitude of the spill, the objectives of a proper response are the same--you must "control" the spill, you must "contain" it, and you must "clean it up". These three steps are frequently referred to as the "Three C" program.

CONTROL THE SPILL

Immediately after a spill has occurred, steps should be taken to control the flow of the liquid being spilled regardless of the source. If a sprayer has tipped over or if a chemical is leaking from a damaged tank truck, or if just a one or five gallon can setting on a storage shelf has rusted through and is leaking, **do everything possible to stop the leak or spill at once.** Smaller containers up to 55 gallons can be put into overpack or larger containers to prevent further release of the chemical. Stopping larger leaks or spills often isn't so simple.

When attempting to control the flow of the chemical, don't expose yourself unnecessarily--wear protective clothing and equipment. Whenever you transport pesticides, carry protective clothing and equipment with you in the vehicle. Don't charge in blindly if someone is injured; again make sure that you are properly protected. You're not going to be able to help anyone if you yourself are injured in the process.

Have someone alert the state, county, or local police if the spill occurs on a public highway. You must also notify the Minnesota Department of Agriculture in the event of any spill. The Minnesota Pesticide Control Law 76 3 MCAR 1.0338 (3) states "persons involved in, or responsible for, an incident involving a pesticide such as flood, fire, tornado, motor vehicle accident, poisioning, exposure, spills or leaking containers likely to cause damage to humans or the environment shall immediately report such incident to the Minnesota Department of Agriculture and provide information as may be requested by the commissioner.

The Minnesota Department of Agriculture can be contacted through the Department of Public Safety, Division of Emergency Services (DES) 24 hours a day, 7 days a week, at **(612) 778-0800.** You may also contact the Department of Agriculture directly at (612) 296-6121 or contact your area Agronomy Services Coordinator. If you contact the Division of Emergency Services the requirements of notifying any other State agency will be satisified, in that, DES will contact all State agencies that will need to be involved in response. Give them the following information:

1. Location of incident.
2. Identity of material involved.
3. Time incident occured.
4. Source of spill.
5. Volume of material and duration.
6. Movement of material--present and anticipated.
7. Nearby surface water or wells.

Bear in mind, however, that someone must remain at the spill site at all times until it has been effectively contained and cleaned up.

Isolate the contaminated area, preferably by roping it off. Keep people at least 30 feet away from the spill. Avoid coming in contact with any drift or fumes that may be released. Do **not** use road flares if you suspect the leaking material is flammable. At times it may be necessary to evacuate people downwind from the spill.

CONTAIN THE SPILL

At the same time the leak is being controlled, contain the spilled material in as small an area as possible--construct a dam to prevent the chemical from spreading. **It is particularly important not to allow any chemical to get into any body of water, including storm sewers.** If contamination of water does occur, report it immediately to the Division of Emergency Services. **Do not hose down the area**; this will cause further spread of the chemical.

Liquid spills can be further contained by spreading absorbent materials such as fine sand, vermiculite, sawdust, or clay over the entire spill; kitty litter is particularly useful for containing and cleaning up small spills or minor leaks. A word of caution, however--avoid the use of sawdust or sweeping compounds if the material is a strong oxidizer. Such a combination presents a possible fire hazard.

This last precaution emphasizes the need for specific information on the particular pesticide. If you don't have safety data sheets on the product, it is always advisable to contact the manufacturer for specific recommendations. Emergency numbers are listed on most product labels. Alternatively, the manufacturer can be contacted through CHEMTREC (800-424-9300) or the Department of Agriculture.

In the case of dust, wettable powder, or granular material, you can reduce further spread by **lightly** misting with water or by covering the spill with some type of plastic cover. Remember, however, that this cover is now contaminated and should be discarded after use.

CLEAN UP THE SPILL If you haven't already done so, spread absorbent material over the contaminated area, sweep it up, and place it in a heavy-duty plastic bag. Keep adding the absorbent until all the liquid is soaked up.

Once the spill has been cleaned up, it may be necessary to decontaminate or neutralize the area, especially if a carbamate or organophosphate insecticide was involved. Although a mixture of full-strength household bleach and hydrated lime is usually an effective decontamination solution, it is again best to obtain recommendations for the specific product. Work the solution into the spill area with a coarse broom. (Remember to wear protective clothing and equipment as needed). Then add fresh absorbent material to soak up the now contaminated cleaning solution. This material should then be swept up and placed in a plastic bag or drum for proper disposal. It will be necessary to repeat this procedure several times to ensure that the area has been thoroughly decontaminated.

If soil becomes contaminated, the only thing that will effectively decontaminate the area is to remove the top two to three inches of soil. Be sure to dispose of the contaminated soil in a proper manner. Then cover the area with at least two inches of lime. Finally, cover the lime with fresh topsoil.

Soils contaminated as a result of application errors or minor spills can sometimes be cleaned up by applying activated charcoal to the contaminated surface immediately after the spill or misapplication has occurred. The charcoal may absorb or tie-up enough chemical to avoid significant plant injury and long-term contamination. Charcoal will not be sufficiently effective, however, where large spills have occurred; soil removal is necessary in these cases.

You must now clean up any vehicles and equipment that were contaminated either as a result of the original accident or during the clean-up procedure. Before you begin, however, be sure you are properly clothed and protected. You can use a liquid bleach-alkaline detergent (dishwater soap) solution to clean equipment. Porous material and equipment such as brooms, leather shoes, and cloth hats cannot be effectively decontaminated and must be discarded or destroyed.

SERIOUS ACCIDENTS Where an accident is particularly serious, either because of the volume or toxicity of the spilled material or because extensive contamination has occurred as a direct consequence of the accident, additional steps beyond those outlined above may be required.

To protect the public and to assist public agencies in handling these mishaps, the chemical industry has developed an emergency response system. The Pesticide Safety Team Network (PSTN) of the National Agricultural Chemicals Association represents a joint effort of technically qualified manufacturers to respond to emergency situations where pesticides or other hazardous chemicals have been accidentally spilled. The PSTN can be reached 24 hours a day through CHEMTREC (Chemical Transportation Emergency Center) at (800) 424-9300.

For you own information, you may wish to obtain "Emergency Response Information Sheets" or "Safety Data Sheets" from those manufacturers that have them available. These provide comprehensive information on the safe handling of the product and appropriate responses to emergencies.

FIRES

Although the majority of pesticide active ingredients are not flammable and do not by themselves constitute a fire hazard, many of the solvents used in liquid formulations are highly flammable. All liquid pesticides should be considered potential fire hazards as well as some wettable powders. Whenever large quantities of pesticides must be stored, it is advisable to install fire-detection devices and to have fire extinguishers and other fire-fighting equipment readily available. It is also a good idea to inform your fire department of the location and identity of any appreciable quantity of stored pesticides.

In the event of a fire, call the fire department and clear all personnel from the area to a safe distance **upwind** from smoke and fumes. Isolate the entire area. Keep spectators out of the downwind area.

If you attempt to fight the fire yourself until the fire department arrives, do so with extreme caution and follow all guidelines outlined below. Always inform the fire department of the nature of the pesticides involved and of any specific information which may help them in fighting the fire and in protecting themselves and others from injury.

Fire-fighting personnel must wear suitable protective clothing and equipment, including liquid-proof gloves, boots, full body-covering, and a hat. Respirators are often necessary and are absolutely essential if a burning structure must be entered for rescue; in this case a self-contained breathing apparatus should be used to provide protection against both toxic vapors and oxygen deficiency.

The fire should always be approached from the upwind side and from a safe distance. Fire-fighting personnel should be aware of the potential for explosion of pesticide containers. The principal objective should be containing the fire and preventing contamination of surrounding areas. Nearby containers should be moved or kept cool. Burning chemicals cannot be salvaged and no attempt should be made to do so.

Only as much water as is absolutely necessary should be used; contaminated runoff can be the most serious problem. (It is, in fact, sometimes better to simply let a fire burn in order to avoid what are often massive problems with contaminated runoff). A fog spray is often more effective than a straight stream of water and usually results in less contamination. Whenever possible, foam or carbon dioxide should be used instead of water. If necessary, dikes should be built to prevent flow of contaminated runoff into lakes, streams, sewers, etc.

Personnel should avoid smoke, fumes, mist and runoff as much as possible. Where pesticide poisoning is know or suspected, the individual should leave or be taken from the fire area. A physician or ambulance should be called and appropriate first-aid procedures should be initiated.

PESTICIDES AND GROUNDWATER

In Minnesota and nationwide, groundwater is an extremely valuable natural resource. Groundwater supplies a large percent of Minnesota's drinking water and is the major source of water for irrigated agriculture.

Because we cannot see groundwater, we tend to ignore it. It is easy to forget that substances used on the surface--such as pesticides--can move down through the soil into the groundwater.

Yet it is important that we do all we can to keep potentially hazardous substances out of groundwater supplies. To help preserve our groundwater resources, we need to understand the relationship between groundwater and pesticides and how to avoid contamination of groundwater by pesticides and their residues.

HOW PESTICIDES GET INTO THE GROUNDWATER

Groundwater and surface water are interrelated. In fact, they are parts of the same natural "plumbing" system called the hydrological cycle.

Some of the water that falls on the earth's surface as rain runs off into lakes and streams, some evaporates, and some soaks down into the soil. Some of the water that enters the soil is retained in the plant root zone and is withdrawn and used by plants. Any water not taken up by plants gradually seeps through the pores between soil particles and enters the deeper layers of soil, gravel, and rock, where the pore spaces are totally filled with water. The water in these layers is the groundwater. In a process called leaching, the water that seeps downward carries with it some water-soluble nutrients, minerals, and other substances that were in or on the soil. In other words, groundwater starts out as surface water which, as it moves down through the soil, can carry other substances such as pesticides or fertilizers along with it.

When someone makes drip coffee, hot water percolates through the coffee grinds, leaching the caffeine and flavoring compounds into the coffee pot. The strength of the coffee depends on the solubility of these compounds and is therefore affected by how much water is poured through the grinds. Similarly, whether pesticides leach down into the groundwater depends primarily on how much water moves through the soil. But it also depends on whether the pesticides adhere to soil particles and whether the pesticides break down, or "degrade", before or while moving through the soil.

In time, pesticides break down into simpler chemical compounds. The breakdown can be caused by reaction with minerals and other natural chemicals in the soil or water, by physical factors such as sunlight or heat, or by bacteria and other microorganisms. The compounds eventually resulting from the breakdown process are usually nontoxic, although some compounds formed in intermediate steps in the process can themselves be toxic. Aldicarb, for example, changes first into aldicarb sulfoxide, which is nearly as toxic as the original compound, and then into aldicarb sulfone, which is less toxic. These compounds eventually break down to harmless carbon dioxide and water.

Therefore, for a pesticide to penetrate into the groundwater and present a hazard, it must move through the soil and it must resist breakdown to nontoxic compounds. Whether this happens depends on three things:

- The nature of the soil.
- The nature of the pesticide.
- The amount and timing of either rainfull or the combination of rainfall and irrigation water applied to the soil.

All three factors work together in a complex way to determine the movement and breakdown of pesticides in the soil.

THE SOIL

Soil type is very important in determining how a pesticide breaks down or moves toward the groundwater. Clay soils, for example, are made up of extremely small particles that together provide a vast surface area for "sorption", or physical attachment, of the chemical pesticide onto the surfaces of the soil particles. Also, the very small size of the pores between clay soil particles slows down the movement of water and dissolved pesticides through the soil. While held securely to soil particles, pesticides are kept from moving to the groundwater, and some pesticides are more likely to be broken down by chemical, physical, or biological factors.

Sandy soils contain larger soil particles that have much less surface area for sorption. These soils also have much larger pores between the particles, and allow water and disolved pesticides to move through more quickly.

Organic matter in the soil is also very important in preventing pesticide movement and promoting pesticide breakdown. Organic matter provides additional surface area for sorption and provides an excellent environment for chemical and biological breakdown.

Because all pesticides break down to simpler substances over time, and most breakdown occurs in the soil, there is a greater potential for groundwater contamination by pesticides in areas where pesticides move quickly through the soil--that is, where soils are sandy and low in organic matter, and the amount of water percolating through the soil from rainfall or irrigation is large.

Soil moisture and temperature also have a great effect on pesticide breakdown. The rate of breakdown decreases in drier soils and at lower temperatures because both chemical and microbial reaction in soil are slower in colder, drier soils.

THE PESTICIDE

The characteristics of the pesticide itself also affect both how it moves through the soil and how it breaks down. Different pesticides have different abilities to adhere by sorption onto soil particles. Some pesticides stick very tightly to soil grains, 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.

Equally important, pesticides and their interim breakdown products differ in their ability to dissolve in water. Pesticides which do not adhere strongly to the soil by sorption and which are very soluble in water can move through the soil to the groundwater much more easily than other pesticides with higher sorption and lower solubility properties.

Pesticides also vary greatly in their rates of breakdown. The inorganic pesticides that were more commonly used many years ago, such as sulfur dust and copper, mercury, and arsenic compounds, change very slowly in the soil and do not really break down. However, these pesticides are now in limited use and are seldom leached from the soil because they are so insoluble and are strongly sorbed. Virtually all modern pesticides are made from synthetic organic compounds and break down more readily, but differ among themselves in their rates of breakdown.

Many pesticides applied as sprays to the leaves of plants are insoluble in water. Particles that remain sticking to the plant leaves, or that fall off or are washed or blown off and land on the soil surface, may be broken down by ultraviolet light from the sun in a process called photolytic decomposition--degradation by sunlight.

Other pesticides degrade only after they enter the soil. Breakdown here occurs through reaction with the mineral constituents of the soil, with the chemicals dissolved in the soil moisture, or by the action of bacteria and fungi in the soil. Most of this breakdown takes place in loose, cultivated surface layers of the soil. The soil in the surface layers is usually the most chemically and biologically active because it tends to be warm, moist, rich in organic matter, and well-aerated.

Generally, the pesticides that are of greatest concern in connection with groundwater contamination are those that present a public health threat because of their potential toxicity to humans or domestic animals. Herbicides, which are designed to control plants, are not generally as toxic to humans or animals as substances such as insecticides or nematicides.

In this manual, we have discussed three broad chemical classes of insecticides: chlorinated hydrocarbons--such as DDT, aldrin, dieldrin, and chlordane; organophosphates--such as phorate (Thimet), fonofos (Dyfonate), Terbufos (Counter), disulfoton (Disyston), malathion, and parathion; and carbamates--such as carbofuran (Furadan), aldicarb (Temik), and oxamyl (Vydate). Organophosphate and carbamate insecticides generally break down more rapidly than chlorinated hydrocarbon insecticides. However, chlorinated hydrocarbon insecticides generally are more sorptive than the organophosphate and carbamate compounds.

In selecting which pesticide to use and considering how to minimize potential effects on groundwater, it is important to consider the pesticide's toxicity, its solubility in water, and its absorption characteristics. For the insecticides we have listed above, for example, these three factors can vary substantially.

The movement of pesticides through the soil and their breakdown can be affected by the amount and timing of water applied to a field, whether the watering occurs naturally by rainfall, artifically by irrigation, or by a combination of the two.

Both soil moisture and temperature can affect the chemical breakdown of a pesticide. Cold rain or irrigation water cools the soil, slowing breakdown reactions. Rain or irrigation water can also wash pesticide residues off of plants and below the soil surface, removing them from the photolytic effects of sunlight. But worse still, too much rain or too much irrigation can cause leaching of water-soluble pesticides through the soil and into the groundwater.

Too much water often moves pesticides beyond the reach of plant roots, resulting in loss of crop protection as well as the undesired problem of surface water or groundwater contamination. Good water management is necessary, especially in coarser irrigated soils, to ensure good pest control and to avoid leaching problems.

The situation is especially critical with soil-incorporated granular systemic pesticides, which must be dissolved out of the carrier granules by the soil moisture before they can be taken up by plant roots. Although systemic pesticides currently in use generally decompose in the soil by the end of the growing season, the solubility of these compounds can create problems when they have not been taken up by plants. During the growing season, too much rain, or a combination of too much rain and irrigation, can leach the pesticide through the soil to the groundwater. Any residues carried over from the growing season can be leached through the soil by heavy rains in the fall, winter, or early spring. The goal in using such pesticides, then, is to add enough moisture to the soil to assure good plant growth and pesticide uptake, but not so much as to wash pesticides down below the reach of plant roots and into the groundwater.

In summary, pesticides can cause groundwater problems by moving down through the soil before being degraded into simpler, nontoxic compounds. The soil, the pesticide itself, the application of water, and other factors all work together in a complex way to affect the movement and breakdown of the pesticide.

WHAT HAPPENS TO PESTICIDES ONCE THEY ARE IN THE GROUNDWATER?

Pesticides continue to break down in the groundwater, but for lack of light, heat and oxygen in the water-saturated layers below the surface, chemical breakdown is generally slower than in the surface layers of the soil. Coarse soils that allow water to pass through so that microbial breakdown of some pesticide residues can still go on, even if only slowly. While breakdown in groundwater might be slow, it is probably constant because groundwater remains warmer in the winter than the frozen surface water and soils.

The movement of groundwater is slow and difficult to trace, and substances such as pesticides that enter the groundwater in one location can unpredictably turn up later in different locations. The difficulty of tracing groundwater movement and the expense of testing the water for pesticides in various locations make it difficult to determine where problems start and to predict where they might show up.

Purification of groundwater that has become contaminated is not easy, and treatment of groundwater by chlorination or with filters on domestic taps, for example, can be expensive and is not always entirely successful. The best policy is to keep hazardous substances out of the groundwater in the first place. The first step toward this goal is for people to become aware of actions on the surface that can cause problems below the surface.

HOW TO AVOID PROBLEMS OF PESTICIDES IN GROUNDWATER

The best way to avoid contamination of water by pesticides is not to use pesticides, but few farmers would agree that this is a very practical solution. On the other hand, we should not automatically use a pesticide once a pest problem has been identified. While chemicals are frequently essential components of pest control programs, other methods or combinations of methods are sometimes more appropriate. Various methods of pest control and the concept of integrated pest management have already been discussed.

Pest control methods should be selected to achieve effective, practical, economical, and environmentally sound control. The last of these considerations is as important as the first three, and protection of groundwater is an important component of environmentally sound pest management. Once a pest problem is identified, a series of intelligent and informed decisions must be made to minimize the potential contamination of groundwater: the decision to use a pesticide; the decision to use it alone or in combination with other pest management procedures; the choice of a particular pesticide; and its proper use according to label directions.

When pesticides are used, it is essential that label directions be followed meticulously and that irrigation schedules be well-planned and followed. This is doubly important if the pesticides used are very soluble in water and are applied on coarse-textured, well-drained soils. The pesticide label is the critical link between the extensive testing of the pesticide before it is registered for public use and its actual use in the field. A pesticide is tested not only for its toxicity but to determine its rate of breakdown under different environmental conditions, its solubility, its movement through various soil types, its reaction with other chemicals in the environment, etc. The label is the result of this extensive testing, and dictates how the pesticide is to be applied, stored, transported, and disposed of. If label directions are carefully followed, problems of groundwater contamination by pesticides can be minimized.

Yet even with all the testing and precautions, unforeseen problems can still occur. What happens then? In Minnesota, the Department of Agriculture (MDA) oversees the use of pesticides and has authority to adopt or change rules to protect people and property when a potential hazard is detected.

Again, the label provides instructions that reflect the best scientific knowledge on the safe and environmentally sound use of the pesticide. When problems are found with the use of any pesticide under certain conditions in a certain location, the product can be removed from the market or the label can be changed to ensure that the pesticide will be used more safely in that location in the future.

Summary

Groundwater is one of Minnesota's truly important natural resources. It provides a vast supply of clean water for use in agriculture, homes, and industry, now and for the future. We can ensure a source of high quality groundwater in the future only if we manage the resource wisely now. The best way to protect the groundwater supply is to understand how groundwater works and how human activities, including the use of pesticides and the application of irrigation water, can affect this valuable resource.

CONTROLLING PESTICIDE DRIFT

THE DRIFT PROBLEM

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

Pesticide drift can harm sensitive crops, ornamentals, gardens, livestock, wildlife, or people. Bodies of water, streams, or buildings can be contaminated. Drift onto crops can result in an illegal residue if the residue on the crop exceeds the level for which tolerances have been established or if no tolerance has been set. Poor performance can result if excessive drift results in too low a rate of application.

FACTORS AFFECTING AND TECHNIQUES FOR CONTROLLING DRIFT

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

Formulation: Vapor drift can be avoided by using relatively nonvolatile formulations and invert emulsions (see table 1). Low volative 2,4-D formulations reduce the vapor drift hazard. Dusts drift more readily than sprays. Measurements of drift from aerial applications showed from 5 to 100 times more drift from dusts than from sprays at distances of 100 feet to 1/2 mile from the flight pattern.

Particle or Droplet Size: Large particles or droplets have less drift potential than smaller particles or droplets (see table 1). But consideration must also be given to adequate coverage.

Spray nozzles produce a wide range of droplet sizes. Thickened sprays are coming into use to increase the percentage of large droplets (see table 2). Thickened sprays, however, do not completely eliminate the fine droplets. Application techniques and precautions are still important in applying thickened sprays to reduce drift problems.

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

Evaporation Rate: After spray droplets are released, evaporation reduces their size, which tends to keep them suspended longer. Water evaporates more rapidly than oils (e.g., 35 times as fast as diesel fuel). Small droplets may completely evaporate before they reach the ground (see table 3).

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

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

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

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

Weather: Weather conditions can affect the potential for drift (see table 4). **Air movement**, both horizontal and vertical, is one factor that can affect this potential.

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

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

Table 1. Distance water droplets drift while falling 10 feet in a 3 mile per hour wind

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

[a]1 micron = 1/25000 inch.

Table 2. Effect of thickening agents on spray drift

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

Table 3. Lifetime of water droplets, 40 percent relative humidity, 59°F.

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

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

Temperature has effects on air movement, as discussed above. In addition, high temperatures increase losses of volatile herbicides. The carbamates, dinitro compounds, and high volatile exters of 2,4-D; 2,4,5-T, and other phenoxy compounds volatilize rapidly at temperatures above 80 F. At temperatures above 90 F, even the low volatile esters of 2,4-D and other phenoxy compounds become significantly volatile.

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

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

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

Table 4. Micro-weather effects on drift

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

SUMMARY

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

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

CHEMICAL APPLICATIONS THROUGH AN IRRIGATION SYSTEM

Application of some types of fertilizer and/or pesticide chemicals by injection into sprinkler irrigation water is a commonly used practice in many irrigated areas of the country. In Minnesota, it is estimated that over 75% of the irrigation systems are equipped with a chemical injection system and use it almost exclusively for applying part of a plant's nitrogen requirement. Very little pesticide application is known to be taking place in Minnesota mainly because of the problem of high winds.

ADVANTAGES AND DISADVANTAGES

This practice offers some distinctive advantages compared to the convention method such as 1) a reduction in manpower and also a saving in equipment cost and maintenance; 2) more efficient usage of nitrogen by applying closer to the time of crop's needs and minimize leaching losses; 3) enough water can be applied with the irrigation sprinkler to move the material into the soil and provide conditions ideal for the materials' activity; and 4) reduce soil compaction. A properly engineered sprinkler system operated at the recommended pressure should provide an excellent distribution of most materials.

On the other hand, this practice of applying chemicals also has some disadvantages such as: 1) possible lack of uniformity of application; 2) loss of some volatile pesticides and ammonia; 3) undesirable side reactions of some chemicals with the water; and 4) a water supply pollution hazard may exist if the proper anti-pollution devices are not installed with the chemical injection equipment.

Two specific pollution hazards are: 1) the irrigation pumping plant may shut down from mechanical or electrical failure while injection equipment continues to operate, causing a mixture of water and chemicals to backflow into the irrigation well or other water source, or possibly causing chemicals to empty unnecessarily into the irrigation system, and 2) the chemical injection system may stop while the irrigation pump continues to operate, causing water to backflow through the chemical supply tank and overflow onto the ground.

INJECTION EQUIPMENT

The most common chemical injection pump for a sprinkler irrigation system is a positive displacement or piston type. The pump should be made out of stainless steel or other non-corrosive chemicals. Injector pumps may be driven by small electric motors (1/3 - 1/2 hp), belt driven from the irrigation pump drive shaft or by water pressure from the irrigation pipe. There are several sizes available to meet the specific irrigation operation's chemical application requirements ranging from less than one to over 200 gallons per hour injection rates. The rate for a given injector pump can be varied by changing the piston's stroke frequency, length of travel of the piston, piston size or number of pistons operating if equipped with more than one.

Other equipment needed includes corrosive resistant suction and discharge lines, suction line screen, chemical storage tank

(1000-1500 gallons) and anti-pollution devices.

ANTI-POLLUTION DEVICES

According to the Minnesota Department of Health's water well construction code an anti-pollution device is required to be installed and maintained at all water wells when another system containing possible pollutants is connected with a well water supply system to prevent a possible pollution hazard to the water supply. The specific rule is recorded in 7 MCAR-1.219, C. Cross Connection and states:

> "Cross connections between water wells and other systems or equipment containing water or other substances of unknown, or questionable safety, including pesticides and fertilizers, are prohibited, except where equipped with a suitable protective device such as a break tank or bankflow preventer which is approved by the Commissioner and which the owner agrees to install, test, and maintain to assure proper operation."

Another rule placing some limits on location of chemical storage to the well is recorded in 7 MCAR-1.217, C., distance from Pollution Sources and states:

> "a. 150 feet from a preparation area or storage area of spray material, commercial fertilizers or chemicals that may result in pollution of the soil or groundwater."

To meet Minnesota's anti-pollution device requirements and avoid a possible water supply pollution hazard, a chemical injection system and anti-pollution equipment should be installed according to the American Society of Agricultural Engineers' Engineering Practice (No. EP409) "Safety Devices for Applying Liquid Chemicals Through Irrigation Systems." The ASAE practice basically defines safety equipment to avoid pollution hazards in the two previously identified areas. These include (1) a backflow prevention device to prevent pollution by flow of a mixture of water and chemical back into the well or other water supply and (2) interlock injection devices to insure that if the irrigation pumping plant stops, the chemical injection pump will also stop and another device to prevent water from flowing back through the injection pump whenever turned off and overflowing the chemical supply tank.

A general description of these recommendations and schematic diagrams are outlined in the Nebraska Extension publication entitled "Anti-Pollution Devices for Applying Chemicals Through the Irrigation System." The AEAE recommendation further defines the backflow prevention device (Neb. Guide refers to it as a check and vacuum relief valve) for pressurized system to include either (1) a pressure vacuum breaker containing, within a single body, a spring-loaded check valve and a spring loaded, air opening valve which opens to admit air whenever the pressure approaches atmospheric and installed only when there can be no back pressure or there are shut off valves downstream of the device; (2) a double check valve containing two single independently acting check valves; or (3) a reduced pressure principle device consisting of two independently acting check valves, together with a pressure differential relief valve located between the two check valves. The first device is probably the most practical and trouble free installation for most irrigation systems applying chemicals to avoid any pollution hazards to the water supply.

INJECTED CHEMICALS

Urea and ammonium nitrate liquid mixtures are the most commonly injected chemicals into irrigation water today. In Minnesota, a 28% nitrogen solution of this mixture is the most commonly used. Simple applications of 20 to 30 pounds of actual nitrogen per acre are probably the most practical. Twice this amount has been known to have been applied with no reported crop or irrigation water or equipment side effects. The highest amount practical will most likely be limited by the specific injection pump's performance.

Anhydrous ammonia has been injected into irrigation water but at the present time is not recommended for use in sprinkler systems because of a couple problems. First of all, it has been demonstrated that as much as 35 to 45% of the nitrogen injected can be lost to the atmosphere as ammonia gas. Secondly, when injected into the water, the pH of the water is raised and this causes precipitation of calcium and magnesium carbonates which will collect on the inside of the pipe and sprinkler nozzles and may plug them.

Some phosphates and potash fertilizers have been tried through sprinkler systems but generally reported without much success. Also, some phosphorus containing fertilizers are very corrosive, especially to brass. If irrigation water is hard, or in other words, contains appreciable amounts of calcium, calcium phosphate may precipitate and clog nozzles.

Other fertilizers such as sulphur and numerous micro nutrients have been reported to have been injected into irrigation water without any observed side effects to irrigation equipment.

Certain preplant and preemergence herbicides have been applied successfully in irrigation water and many currently are registered for application through sprinkler systems. Some of these include Eradicane, Sutan +, Sutan + and atrazine, Lasso, and Lasso plus atrazine. Most herbicides are best injected when mixed with some water. To prevent settling out of the chemical, the herbicide solution in the storage tanks should be agitated all the time. No reports have been recorded of any reactions of herbicides with the water or equipment.

Other chemicals such as insecticides and fungicides have also been tried by a few with limited reports on success available.

Application of herbicides, insecticides, etc., by sprinkler systems should be avoided when wind speeds exceed 19 mph. Strong winds can result in uneven application of water and chemicals. Also, drift may occur into adjacent areas and become a problem in strong winds.

CALIBRATION

It should be noted that research is constantly being conducted on chemigation. As the results of this research become known new uses, limits, restrictions and laws may be enacted. Consult your county agent on the current status of allowable use of chemigation.

In order to capitalize on the convenience of applying agricultural chemicals through sprinkler irrigation systems and obtain effective results, accurate amounts evenly distributed over the field at the correct time must be accomplished.

To accurately determine a chemical's injection rate to meet its application requirements, follow the method described in Nebraska Extension publications "Fertilizing Through Center Pivots" or "Applying Herbicides in Irrigation Water" or an injection pump operating manual.

CHEMIGATION SAFETY CHECKLIST

The application of agricultural chemicals through an irrigation system, chemigation, has proven itself to be an effective alternative application method provided the chemical is suited for the practice and the irrigation system is properly engineered to handle the chemical safely. Pollution hazards and others can be avoided by utilizing the proper equipment, hookup and operating practices. The following checklist identifies the basic safety equipment and operating procedures that should be adopted before a decision to chemigate is given the green light.

- An interlock between the power systems of the center pivot, irrigation pumping plant and the chemical injection unit so that if the irrigation system or pump shuts down the injector pump will also stop. For pesticides, it would be best to have this interlock work also in reverse direction so that when even the injector system stops injecting the chemical the entire system shuts down.

- A check and vacuum relief valves (anti-siphon or backflow preventer devices) positioned in the irrigation pipeline between the irrigation pumping plant and the point of chemical injection. The check valve should give a positive closing action and a watertight seal.

- A check valve in the chemical injection discharge line. For additional protection a small, normally closed solenoid valve located in the suction line between the chemical supply tank and the injector pump.

- A check valve in the chemical injection discharge line. For additional protection a small, normally closed solenoid valve located in the suction line between the chemical supply tank and

the injector pump.

- A strainer on the chemical suction line to prevent clogging or fouling of the injector pump, check valve or other equipment.

- Do not apply chemical when winds are greater than 10 mph.

- Do not apply chemicals on open waters in the field.

- never chemigate in the first pass of the season.

The Minnesota Department of Health's water well construction code, currently, states that all chemical injector/water systems shall have a suitable protective device such as a break tank or backflow preventer device that is approved by the commissioner. To date, the commissioner has not given any specifications for such devices but is reviewing actions of other states.

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GLOSSARY

Abrasion- A scrape, scratch, sore or cut that breaks skin.

Abrasive- Something that grinds down or wears away an object. Example: wettable powders are abrasive to pumps and nozzles and wear them down quickly.

Absorptive Clay- A special type of clay powder which can take up chemicals and hold them. It is sometimes used to clean up spills of pesticides.

Accumlative Pesticides- Those chemicals which tend to build up in animals or the environment.

Acid- A very sharp, sour liquid which is usually very dangerous in concentrated form.

Acre- 43,560 square feet. An area of land about 209 feet long by 209 feet wide.

Activated Charcoal- Very finely ground, high quality charcoal which absorbs liquids and gasses easily.

Actual Dosage- The amount of active ingredient (not formulated product) which is applied to an area or other target.

Acute Poisoning- Severe poisoning which occurs after one exposure to a pesticide.

Adhesive- An adjuvant which helps the pesticide stick to the treated surface.

Agitate- To keep a pesticide chemical mixed up; to keep it from settling or seperating in the spray tank.

Alkali- Opposite of an acid; it is usually dangerous in concentrated form.

Anti-siphoning Device- A small piece of equipment attached to the filling hose to prevent fill water from draining back into the water source. Example: check valve.

Apiary- Place where colonies of bees are purposely kept.

Application- Putting a pesticide on or in plants, animals, buildings, soil, air, water, or other target to kill pests or prevent damage by them.

Artificial Respiration- First aid for someone who has stopped breathing, by blowing air into his lungs or applying pressure to back to start breathing again.

Atropine- An antidote for organophosphate and carbamate poisoning. Full name is atropine sulfate.

Attractive Nuisance- a legal term for any object which might attract children or other persons to it and then might injure or hurt them as a result. Examples: sprayers, empty pesticide containers.

Avoid- Don't do it. For example "avoid spraying on windy days" means don't spray on windy days.

Bait- A food or other material which will attract a pest to a pesticide or to a trap where it will be destroyed.

Base- Alkali; opposite of an acid.

Blanket Application- Application of a chemical over an entire area.

Boom- Several nozzels joined together by sections of pipe or tubing to apply pesticides over a wide area at one-time.

Broad Spectrum Pesticides- General purpose materials with a wide range of uses. They are effective when several different pests are a problem.

Calculate- Do some arithmitic; work with numbers, determine, figure out.

Calibrate (Calibration)- To figure or measure how much pesticide will be applied by the equipment to the target.

Cancelled- A pesticide use that is no longer registered as a legal use by the Environmental Protection Agency. Remaining stocks can be used by order of the Administrator, EPA.

Carbamate Pesticide- A particular family of pesticides which are chemically simular. They all attack a pest in the same way. Common ones are carbaryl (Sevin), carbofuran (Furadan) and methomyl (Lannate).

Cartridge- The cylider-shaped part of the respirator which absorbs the fumes and vapors from the air before you breathe them. It should be replaced often.

Caution- A signal word used on labels of pesticides to alert users that the pesticide is slightly toxic.

Chemically inactive- Will not easily react with any other chemical or object. Examples: talc, clay.

Chemical Reaction- When two or more substances are combined and, as a result, undergo a complete change to make new substances or materials.

Chronic Poisoning- Poisoning which occurs as a result of small, repeated doses of pesticide over a period of time.

Circulate- To move completely through something in a path that returns to the starting point.

Combustible- Will burn if near an open flame or spark.

Commercial- A job or business whose purpose is to make money or earn a profit.

Concentrate- A pesticide as it is sold, before diluting it. Usually contains a lot of active ingredient.

Condemnation- The act of removing a crop or product which does not meet legal standards for tolerances on foods and thus is not to be sold.

Contact- To touch or be touched by.

Contaminate- Pollute by the addition of an unwanted material (often a pesticide) where it could do harm or damage.

Control- To reduce damage; to keep down the number of pests in an area.

Corrosion- The effect of being worn down or eaten away slowly.

Corrosive Poison- A type of poison containing a strong acid or base which will severely burn the skin, mouth, stomach, etc.

Cross Contamination- When one pesticide gets into or mixes with another pesticide accidentally--usually occurs in carelessly handled pesticide containers or in poorly cleaned sprayer.

Days to Harvest- The least number of days allowable between the last pesticide application and the harvest date, as set by law.

Days to Slaughter- The least number of days allowable between the last pesticide application and the date the animal is slaughtered, as set by law.

Decontaminate- To remove or break down the unwanted material (usually pesticide) so it cannot do any harm or damage.

Degrade- Break down, decompose.

Degree of Exposure- The amount or extent to which a person has been in contact with a toxic pesticide.

Deposit- The pesticide on the leaves or skin or other surface right after a pesticide application.

Deteriorate- To decay, to wear away, to break down.

Dilute- To make a pesticide thinner or weaker by adding water, oil, or other material; to "water down."

Disinfectant- A pesticide or other chemical that kills or inactivates disease-producing microorganisms such as bacteria.

Disposal- The act or process of discarding or throwing away a pesticide. Should be done carefully and safely.

Domestic Animal- Tame animal used for man's benefit. Examples: cow, sheep, horse.

Downwind- On the side which the prevailing wind is blowing toward.

Drift- The movement by wind and air currents of droplets or particles of a pesticide from the target area to an area not intended to be treated.

Dust- A finely ground, dry mixture containing a small amount of pesticide and an inert carrier such as talc or clay. The dust particles are of many different sizes.

Ecology- Study of the relationship between a plant or animal and its surroundings.

Edible Parts- Parts of a plant that are used for human or animal food.

Emetic- Something that causes vomiting in order to get rid of poison in the stomach.

Emulsifier- A chemical which helps one liquid form tiny droplets and thus remain mixed in another liquid. It is used to form a stable mixture between two liquids which usually would not mix, like oil in water.

Encapsulation- Method of disposal of pesticides and pesticide containers by sealing them in a sturdy, waterproof container so the contents cannot possibly get out. Also, a method of formulating pesticides.

Environment- Surroundings--usually water, air, soil, plants, and wildlife.

Environmental Protection Agency (EPA)- The federal agency responsible for pesticide rules and regulations.

EPA Registration Number- A number assigned by EPA to a product when it is registered that must appear on all labels for that product. It will appear as "EPA Reg. No." or "EPA Registration No." followed by the company number and product number. Sometimes a state alphabetical designation and distributor's number will appear.

Eradicant Fungicide- Type of fungicide which kills the disease after it appears on or in a plant.

Evaporate- To form a gas and disappear into the air.

Exemption- Exception.

Expose - Exposure- Not shielded or protected; to come in contact with the pesticide.

Face Shield- A transparent piece of protective equipment used by a pesticide applicator to protect ones face from exposure to pesticides.

Feed- Food used for the purpose of feeding livestock and domestic animals.

Filter- To screen out the unwanted material; clean by straining out the undersirable parts; or a piece of equipment for doing this.

Finite Tolerance- The maximum amount of pesticide which can remain on food or feed crops at harvest after the pesticide has been directly applied to the crops.

Flowable- Very finely ground solid materials of pesticide which are mixed in a liquid carrier.

Fluid- Liquid.

Foaming Agent- Chemical substance which causes the pesticide mixture to form a thick foam. It is used to reduce drift.

Fogger- Aerosol generator; a piece of pesticide equipment that breaks some pesticides into very fine droplets (aerosols or smokes) and blows or drifts the "fog" onto the target area.

Foliage- Leaves, needles or blades of a plant.

Foliar Sprays- Pesticides whch are applied on the stems, leaves, needles, or blades of a plant.

Formula- A brief way of writing a complicated idea by using abbreviations and symbols.

Fume- Unpleasant or irritating smoke, vapor or gas.

Fumigation- The use of a fumigant to destroy a pest.

Gas Mask- Type of resirator which covers the entire face and protects the eyes as well as the nose and mouth. Masks contain better filters and more absorbing material to cleanse the air than cartridge resirators and are less likely to leak around the edges.

Germination- Sprouting of seeds.

Granary- A storage area for threshed grain.

Hydraulic Agitator- a device which keeps the tank mix from settling out by means of water flow under pressure.

Hydraulic Sprayer- A machine which applies pesticides by using water at high pressure and volume to deliver the pesticide to the target.

Illegal Residue- A quanitity of pesticide remaining on the crop at harvest which is either above the set tolerance or which is not allowed on the crop at all.

Immune- Not susceptible to a disease or poison.

Inactive- Will not react chemically with anything; not involved in pesticide action.

Incinerator- A high heat furnace or burner which reduces everything to ashes and vapors or non-harmful residues.

Incompatible- Not able to be mixed or used together.

Incorporate- To work or blend a pesticide into the soil completly.

Infestation- Any pests found in an area or place where they are nor desirable.

Ingest- To eat or swallow.

Ingredient Statement- Tha part of the label on a pesticide container which gives the name and amount of each pesticide chemical and the amount of inactive material in the mixture.

Inhalation- To take air into the lungs, to breathe in.

Inhalation Toxicity- How poisonous a pesticide is to man or an animal when breathed in through the lungs.

Inject- To force a pesticide chemical into a plant, animal, building, or the soil.

Integrated Control- A system in which two or more methods are used to control a pest. these methods may include cultural practices, natural enemies, and selective pesticides.

Interval- Peroid of time. The time peroid between two pesticide applications or between the last pesticide application and harvest.

Invert Emulsifier- An agent or additive which allows water to remain suspended in oil rather than settling out. The usual emulsifier allows suspension of oil in water.

Irritating- Annoying. Making an animal (or person) uncomfortable by burning, stinging, tickling, making the eyes water, etc.

Kg or Kilogram- A unit of weight in metric system equal to 2.2 pounds.

Larvae- Young, worm-like forms of insects.

Lethal- Deadly, toxic.

Liable/Liability- Legal responsibilty for.

Limitation- Restriction, the most that is allowed.

Liter- A unit of volume in the metric system equal to a little more than one quart.

Material- A substance, often used to mean a pesticide chemical.

Maximum Dosage- The largest amount of a pesticide chemical that is safe to use without resulting in excess residues or damage to whatever is being protected.

Mechanical Agitator- A device which keeps the pesticide and any additives thoroughly mixed in the spray tank by paddling, swirling or stirring.

Metric- A system of measurement which is used by most of the world and which is used in scientific work. It uses meters, grams, and liters as units.

Mg or Millegram- A unit of weight in the metric system; about 28,500 mg equals one ounce.

Misdiagnose- To make a mistake in deciding what pest has caused the problem.

Mite- A tiny animal which is very simular to an insect but has eight legs rather than six. Its body is divided into two parts and it has no antennae (feelers).

Miticide- Acaracide, a pesticide used to control mites and ticks.

Mold- A growth caused by a fungus which is often found in damp or decaying areas or on living things.

Monitoring System- A regular system of keeping track and checking up on whether pesticides are escaping into the environment.

Multipurpose- Doing more than one job, a pesticide which kills more than one pest (broad spectrum).

Natural Enemies- The predators and parasites which exist in the environment and attack pest species.

Negligible Residue- A tolerance which is set on a food or feed crop which will have very small amount of pesticide at harvest as a result of indirect contact with the chemical.

Nematode- A tiny, hair-like round worm that causes damage by feeding on roots or other plant parts.

Nervous System- The brain, spinal cord and nerves of animals.

Neutralize- To destroy the effectiveness of, to counteract.

Non-accumulative- Will not build up in an animal's body or in the environment.

Non-labeled- Use or method which is not written on the pesticide label and therefore is not legal.

Non-persistent- Only lasts a short time (a few weeks or less) after being applied, breaks down rapidly in the environment.

Non-selective Pesticide- a pesticide chemical that will control a wide range of pests.

Non-target- Any plant, animal or other organism that a pesticide application is not aimed at but may accidently by injured by the chemical.

Non-volatile- A pesticide chemical that does not evaporate (turn into a gas or vapor) at normal temperatures.

Operating Speed- The steady rate which your pesticide sprayer is moving along the ground--usually measured in miles per hour or feet per minute.

Oral- Through the mouth.

Original Container- The package (bag, can, bottle, etc.) which a pesticide is sold in. The package must have a label telling what the pesticide is and how to use it correctly and safely.

2-PAM or Protopam Chloride- An antidote used for organophosphate poisoning, but not carbamate poisoning.

Parasite- A plant or animal that harms another living plant or animal (called the host) by living or feeding on or it it. Sometimes parasites are helpful to man by attacking and controlling pests which could injure crops or animals. These paarsites are forms of biological control.

Parts per Million (PPM)- The amount of pesticide that remains on or in a plant, animal, food, or feed crop after treatment (residue) is often measured in parts per million.

Penetrant- A kind of additive or adjuvant which aids the pesticide in getting through the outer surface (leaf, root, skin) and into the plant.

Percent by Weight- The amount of actual pesticide chemical in a mixture based on its weight compared to the weight of the whole mixture. Example: one pound of actual pesticide plus three pounds of other materials would give you a 25% pesticide by weight mixture.

Persist- To stay for a peroid of time; to remain.

Pesticide Kill- When careless or improper use of a pesticide results in death of a large number of non-target organisms.

Plant Diseases- Sicknesses which affect plant life, usually caused by fungi or bacteria.

Point of Drip or Runoff- When a spray is applied until it starts to run or drip off the ends of the leaves and down the stems of plants or off the hair or feathers of animals.

Poison- Any chemical or agent that can cause illness or death when eaten, absorbed through the skin, inhaled, or otherwise absored by humans, animals, or plants.

Poison Control Center- An agency (usually a hospital) in all the major cities which is informed of the proper first aid and antidotes for poisoning emergencies--including pseticide poisoning.

Pollinators- Bees, flies and other insects which visit flowers and carry pollen from flower to flower for many plants to produce fruits, vegetables, nuts and seeds.

Pollute- To make unclean or unsafe through carelessness or misuse.

Port of Entry- Place where foreign goods (plants, animals, crops, etc.) enter the United States.

Potency- The strength of something. Example: how deadly a poison is.

Precautions- Safeguards; safety measures; warnings.

Pre-harvest- The time period just before a crop is ready to be picked, cut or dug.

Pressure- The amount of force on a certain area. The pressure of a liquid pesticide forced out of a nozzle to form a spray is measured in pounds per square inch (psi).

Product- A term used to describe the pesticide as it is sold--it usually contains the pesticide chemical plus a number of additives.

Properties- The characteristics or traits which describe a certain chemical or other thing.

Protective Gear- Clothes and equipment that guard a person against injury or death when using poisonous pesticides. They would include gloves, apron, shoes, coveralls, hat, cartridge, resirator and gas mask.

Rate- The amount of a material which is being delivered to a plant, animal or surface. Usually measured as per acre, per 1000 square feet, or per hour.

Recommended Dosage- Advice from a Count Agent, Extension Specialist or other authority or written on the label on how much of a pesticide to use for preventing damage by or destroying a pest. This amount is not always the maximum allowed by law.

Reentry Interval- Peroid of time between a pesticide application and when workers can safely go back into an area without protective clothing.

Registration- Approval by the EPA of a pesticide for uses as stated on its label.

Regulatory Officals- Those persons working for the federal or state government who enforce the rules and laws.

Residual Pesticide- A pesticide that can destroy pests or keep them from causing damage for long periods of time after it is applied (days, weeks, months).

Respirator- A face mask which filters out poisonous gases and particles from the air so that a person can breathe and work safely.

Restrictions- Limitations.

Runaway Pests- Insects, diseases, weeds, or other pests which get into an area for the first time and therefore have no natural enemies--they often reproduce in large numbers and over run an area.

Scientific Name- The name used throughout the world by scientists for each plant and animal. The names are based on the Latin or Greek languages.

Seizure- To take or impound a crop or animal if it contains more than the allowable pesticide residue.

Selective Pesticide- Controls only certain or limited types of targeted pests. For example, a selective herbicide may only control broadleaf plants and not other plants.

Sensitive Areas- Places where pesticides could cause great harm if not used with special care and action. Examples: houses, barns, parks, ponds, streams, etc.

Sensitive Crops- Crops which are easily injured by pesticide chemicals--even slight drift could cause a lot of damage.

Shock- The severe reaction of the human body to a serious injury which can result in death if not treated, even if the injury itself would not.

Short Term Pesticide- A pesticide which breaks down almost immediately after application into nontoxic by-products.

Signal Word- Word which must appear on pesticide labels to show how toxic the pesticide is. The signal words used are "Danger-Poison" or "Warning" or "Caution."

Soil Fumigant- A pesticide which is added to the soil and takes the form of gas or vapor to kill many pests. Often a tarpaulin, plastic sheet or layer of water is used to trap the gas in the soil until it does the job.

Soluble Powder- A finely ground, solid pesticide that will dissolve in water or another liquid to be applied.

Space Spray- a pesticide which is applied in the form of tiny droplets which fill the air and destroy insects and other pests, either inside or out-of-doors.

Species- A group of living organisms which are very nearly alike, are called by the same common name and can interbreed successfully. Examples: dogs or chickens or German cockroaches.

Spray- A mixture of a pesticide with water or other liquid applied as tiny droplets.

Spray Concentrate- A liquid formulation of pesticide that is diluted with another liquid (usually water or oil) before using.

Stage of Development- Time period during the growth from newborn or egg to adulthood. Example: an insect goes through many changes from egg to adult--any one of these changes is a stage of development.

Sterilize- Treat with a chemical or other agent to kill every living thing in a certain area.

Structural Pests- Insects, rodents and other pests which attack and harm barns, houses, and other buildings. Examples: termites, carpenter ants.

Suction Hoses- The hose through which water is pulled from a pond or stream, or spray from the spray tank to the pump.

Surface Spray- A pesticide spray which is applied in order to completely cover the entire outside of the object to be protected.

Surface Water- Rivers, lakes, ponds, streams, etc. which are located above ground.

Swath- The width of the area covered by a sprayer making one sweep or one trip across the field or other treated area.

Symptom- A warning that something is wrong. An outward signal of a disease or poisoning in a plant or animal.

Target- The area, buildings, plants, animals, or pests intended to be treated with a pesticide application.

Test Animals- Laboratory animals, usually rats, fish, birds, mice, or rabbits, used to determine the toxicity and hazards of different pesticides.

Thermal- Related to heat.

Tick- A small, eight legged, blood sucking insect-like organism often found on dogs, cows or wild animals.

Toxic- Poisonous, deadly, injurious to plants, animals or humans.

Treated Area- A building, field, forest, garden or other place where a pesticide is applied.

Ultra-Hazardous- a job or activity that is very dangerous.

Unauthorized Persons- People who have no right doing something because they have not been told or trained to do it.

Uncontaminated- Does not contain hazardous pesticide residues.

Underground Water- Waterways which are located beneath the soil surface and from which wells get their water.

Uniformly- Done exactly the same way each time or over each area. Done evenly.

Uniformed Persons- People who are not trained to use and handle pesticides safely.

Unintentionally- Did not mean to do it; accidentally.

USDA- United States Department of Agriculture.

Vapor- Gas, steam.

Vaporize- Evaporate, become a gas.

Vermin- Pests, usually rats, mice, or insects.

Victim- Someone who is injured, poisoned or hurt in any way.

Volume- The amount, mass or bulk.

Vomitus- Matter which is vomited.

Appendix 1

TABLE OF COMMON NOZZLES AND THEIR USE, PESTICIDE RECOMMENDATION, OPERATING PRESSURE, AND PERCENT OVERLAP

Nozzle	Use	Pesticide	Operating PSI	% Overlap
Regular Flat Fan	Broadcast	Herbicides Insecticides	15 - 40	33%
Even Flat Fan	Banding	Herbicides	15 - 35	None
Off Center Flat Fan	Broadcast	Herbicides	15 - 40	33%
Flooding Flat Fan	Broadcast	Herbicides Fertilizers	8 - 20	100%
Hollow Cone (core or disc)	Broadcast	Insecticides Fungicides	40 - 400	Directed Spray
RA Raindrop	Broadcast	Herbicides	30 - 60	100%
Broadcast (Boomless)	Broadcast	Herbicides Insecticides	20 - 40	None

Appendix 2
List of Pesticides of Which Certain Formulations are Restricted Use Pesticide (RUP), and Reasons for Restrictions.

ACTIVE INGREDIENT	TRADE NAME (S)	ACTION	CRITERIA INFLUENCING RESTRICTION
Aldicarb	Temik	Insecticide Nematicide Acaricide	Ag. uses - voluntary Accident history
Aluminum Phoshide	Phostoxin Detia	Fumigant	Human Inhalation Hazard
Calcium Cyanide	Cyanogas	Fumigant Rodenticide	Human Inhalation Hazard
Carbofuran	Furadan	Insecticide Nematicide	Acute Inhalation Toxicity Acute Toxicity (oral, dermal and inhalation)
Demeton	Systox	Insecticide	Acute oral and dermal toxicty
Disulfoton	Di-syston	Systemic	Acute dermal and inhalation toxicity
Ethoprop	Mocap	Nematicide Soil insecticide	Acute dermal toxicty
Ethyl Parathion	Several Manufacturers	Insecticide	Human inhalation hazard Acute dermal toxicity Residue effects on mammalian, avian and aquatic species.
Fonofos	Dyfonate	Soil insecticide	Acute dermal toxicity
Methomyl	Lannate Nudrin	Insecticide	Residue effects on mammalian species. Accident history.
Paraquat	Paraquat CL	Herbicide	Human toxicity data. Use and accident history
Permethrin	Ambush	Insecticide	Registration action. Possible adverse effects on aquatic organisms
Phorate	Thimet	Soil and systemic insecticide	Acute dermal toxicity Residue effects on mammalian an avian species.
Picloram	Tordon	Herbicide	Hazard to non-target plants, both crop and non-crop.

Appendix 3

Medical Antidotes for Pesticide Poisoning
(For Your Physician's Use if Needed)

Antidotes such as those described below should be prescribed or given only by a qualified physician. They can be very dangerous if misused.

GROUP I ORGANOPHOSPHATES

Azodrin, Bidrin, Bomyl, carbophenothion (Trithion), Co-Ral, Dasanit, DDVP (Vapona), demeton (Systox), Diazinon, dimethoate (Cygon), dioxathion (Delnav), Di-Syston, Dursban, Dyfonate, EPN, ethion, famphur (Warbex), fenthion (Baytex), Guthion, Meta-Systox-R, Methyl parathion, Monitor, paration, phorate (Thimet), Phosdrin, phosphamidon, Schradan (OMPA), Supracide, TEPP.

ANTIDOTES

1. **Atropine Sulfate** is used to counteract the effects of cholinesterase inhibitors. Injections should be repeated as symptoms recur.

2. **Protopam Chloride (2-PAM)** should also be injected to counteract organophosphate poisonings. It is given intravenously.

Do Not Use morphine, theophyllin, aminophyllin or barbituates.

GROUP II CARBAMATES

Carzol SP, mexacarbate (Zectran), aldicarb (Temik), carbofuran (Furadan), methomyl (Lannate), carbaryl (Sevin).

ANTIDOTES

1. **Antropine Sulfate** is used to counteract the the effects of cholinesterase inhibitors. Injections should be repeated as symptoms recur.

2. **Do Not Use** Protopam Chloride (2-PAM).

GROUP III CHLORINATED HYDROCARBONS

Endrin, dieldrin aldrin, lindane, endosulfan (Thiodan).

ANTIDOTES

1. **Barbituates** for convulsions or restlessness.

2. **Calcium Gluconate** give intravenously.

3. **Do Not Use** epinephrine (adrenalin).

GROUP IV INORGANIC ARSENICALS

Sodium arsenite, Paris green.

ANTIDOTES:

1. **BAL (dimercaprol)** is specific for arsenic poison. Inject intramuscularly.

GROUP V CYANIDES	For Poisons Such As: hydrogen cyanide, Cyanogas.
ANTIDOTES:	1. **Amyl Nitrate** through inhalation. 2. **Sodium nitrite** given intravenously. 3. **Sodium Thiosulfate** given intravenously.
GROUP VI ANTICOAGULANTS	For Poisons Such As: warfarin, Fumarin, Pival, PMP (Valone), diphacinone (Diphacin).
ANTIDOTES:	1. **Vitamin K** by mouth, intramuscularly, or intravenously. 2. **Vitamin C** useful adjunct.
GROUP VII FLUOROACETATES	For Poisons Such as: sodium fluoroacetate (1080).
ANTIDOTES	1. **Monacetin (glycerol monoacetate)** intramuscularly.
GROUP VIII DINITROPHENOLS	For Poisons Such As: DNOC, DNOCHP, dinoseb (DNBP, Premerge).
ANTIDOTES:	1. **Do Not Use atropine sulfate.** 2. Maintain life supports. 3. **Sodium Methyl Thiouracil** may be used to reduce basal metabolic rate.
GROUP IX BROMIDES AND CARBOXIDES	For Poisons Such As: methyl bromide, Carboxide, ethylene dibromide.
ANTIDOTES:	1. **BAL (dimercaprol)** may be given before symptoms appear. 2. **Barbituates** for convulsions.
GROUP X CHLOROPHENOXY HERBICIDES, UREAS, MISCEL-LANEOUS	For Poisons Such As: 2,4-D, 2,4,5-T, silvesx (2,4,5-TP), monuron (Telvar), diuron (Karmex), Hyvar-X, endothall, Diquat, Paraquat.
ANTIDOTES:	1. None. 2. Maintain life supports.

PESTICIDE TOXICITIES

The following is a list of acute oral, dermal, and inhalation (where applicable) toxicities for pesticide active ingredients. Where different values have been reported, a range from the lowest to the highest is given; variations are a result principally of different testing procedures and materials. In most instances the active ingredient is listed by common name; where there is no officially approved common name, either the chemical name or trade name is used. All values given are for rats except where otherwise noted. Where no value is listed, toxicity data was not available. This list is not complete.

The pesticide label acute toxicity ranges:

Toxicity Level	**Pesticide Label**	**Oral LD-50**	**Dermal LD-50**
Highly toxic	Danger/Poison	Less than 50 mg/kg	Less than 200 mg/kg
Moderately toxic	Caution	50 - 500 mg/kg	200 - 2,000 mg/kg
Slightly hazardous	Warning	500 - 5,000 mg/kg	2,000 - 20,000 mg/kg

Common Name	**Trade Name(s)**	**Oral LD-50 mg/kg**	**Dermal LD-50 mg/kg**
acephate	Orthene	866-945	2,000(rb)
acifluorflen	Blazer	1,300-3,300	---
acrolein	Aqualin	46	---
alachlor	Lasso	1,200-9,300	5,000-10,200+rb
aldicarb	Temik	0.79-1.0	2.5-7
aldrin	several	38-67	98-200+
aluminum phosphide	Phostoxin	---	---
		Inhalation LC-50 (ppm)	11
ametryn	Evik	475-1,405	2,500+
4-aminopyridine	Avitrol	20	---
amitrol	several	24,600	---
ammonium sulfamate (AMS)	Ammate	1,600-3,900	---
anilazine	Dyrene	2,710	---
antu	Antu	2-6	---
		4,250 (monkey)	
asulam	Asulox	8,000+	---
atrazine	several	660-3,080	---
azinphosmethyl	Guthion	11-16.4	220
<u>Bacillus thuringiensis</u>	several	8,500	---
barban	Carbyne	600-1,350	---
benefin	Balan	5,000-10,000+	---
benomyl	Benlate	10,000+	---
bensulide	Prefar	770-1,082	3,950+(rb)
bentazon	Basagran	1,100	---
bifenox	Modown	10,000+	10,000+(rb)
borates	several	2,000-5,560	---
borax	several	2,500-5,190	---

Adapted from Pesticide Toxicities, Leaflet 21062, Division of Agricultural Sciences, University of California, February, 1979.
Toxicity for Norway rat; less toxic to other rats and relatively safe for domestic animals. (rb) = rabbit + = greater than

Common Name	Trade Name(s)	Oral LD-50 mg/kg	Dermal LD-50 mg/kg
brodifacoum	Talon	0.27	50
bromacil	Hyvar	570-5,200	2,500+
bromadiolone	Maki	1,13	---
bromoxynil	several	190-270	---
butylate	Sutan	4,000-5,431	4,640+(rb)
cacodylic acid	several	700-1,350	---
captafol	Difolatan	4,600-6,200	15,400
captan	Captan, Orthocide	9,000-15,000	---
carbaryl	Sevin, Savit	500-850	4,000
carbofuran	Furadan	8-11	1,000
carbon disulfide	several	16-200	---
		Inhalation LC-50(ppm)	200
carbon tetrachloride	several	5,730-7,500	---
		Inhalation LC-50(ppm)	300
carboxin	Vitavax	3,820	8,000
CDAA	Randox	700-750	360
CDEC	Vegadex	850	---
chloramben	Amiben	3,500-5,620	3,136
chlordane	several	250-590	690-840
chloroneb	Demosan	11,000+	5,000
chlorophacinone	Chlorophacinone	2.1-20.5	200
		Inhalation LC-50(ppm)	20
chloropicrin	several	0,8-250	---
chloroxuron	Tenoran	3,000-5,400	10,000
chlorpropham (CIPC)	several	3,800-8,000	---
chlorpyrifos	Lorsban	82-276	202
copper chelate	several	650-2,420	---
copper sulfate	several	3000	---
crotoxyphos	Ciodrin	21,125	202-375
cyanazine	Bladex	149-391	2,000
cycloate	Ro-Neet	1,660-4,100	2,450
			4,640
cycloheximide	Acti-dione	1.8-2.5	---
2,4-D	several	300-1,0001	---
2,4-DB	several	500-1,960	10,000
dalapon	several	940-9,330	5,000
			2,000
DCNA (dicloran)	Botran	1,500-5,000+	---
DCPA	Dacthal	3,000+	10,000
DDT	---	113-118	2,510
demeton	Systox	2.5-6.2	8.2-1.4
diallate	Avadex	395-760	2,180
diazinon	several	300-400	600-2,000
dicamba	Banvel	1,028-1,040	1,000
dichlobenil	Casoron	2,700-6000	500-1,350
diclofop methyl	Hoelon	2,176	640+(rb)
dichlone	Quintar	1,300-2,250	2,250
dieldrin	several	46-63	52-117
difenzoquat	Avenge	270-730	3,540
dimethoate	Cygon,De-Fend	215-380	610
dinocap	Drathane	980-1,190	9,400

Common Name	Trade Name(s)	Oral LD-50 mg/kg	Dermal LD-50 mg/kg
dinoseb(DNBP)	Premerge	37-60	100-200
diphacinone	Diphacinone,Diphacin	1.0-3	---
diphenamid	Dymid,Enide	700-1,798	6,320 2,000+ (rb)
diquat	several	400-440	3,000
disulfoton	Di-Syston	2.3-12.5	6.15
diuron	Karmex	1,160-3,400	2,500
dodine	Cyprex	660-1,550	1,500
endosulfan	Thiodan	18-110	74-359
endothall	Endothal	38-58	1,000
EPN	EPN	8-36	25-230
EPTC	Eptam, Eradicane	1,652	10,000
ethazol	Terrazole	1,300-2,000	---
ethofumesate	Nortron	1,200	---
enthoprop	Mocap	61,5	25.9
ethylene dibromide (EDB)	several	117-178 Inhalation LC-50(ppm)	125-300 200
fenaminosulf	Lesan	60-64	100+
fenamiphos	Nemacur	8.1-9.6	73-84
fenac	Fenac	1,780-3,000	3,160
fenthion	Baytex	190-300	330
fenuron-TCA	Urab	4,000-5,700	---
ferbam	several	17,000	1,000
fixed coppers	several	300-1,000	8,000
fluchloralin	Basalin	1,550	---
fonofos	Dyfonate	8-27	147 25
fosamine	Krenite	24,400	1,683
glyphosate	Roundup	4,320	7,940
heptachlor	several	40-188	119-320
hexachlorobenzene	Granox	5,000	---
hexazinone	Velpar	1,690	5,278
iprodione	Rovral	3,500	---
isofenphos	Amaze	28-39	---
isopropalin	Paarlan	5,000	---
karbutilate	Tandex	3,000	15,400
linuron	Lorox	1,180-4,00	2,500
MAA	several	1,800	---
malathion	Cythion, Malathion	1,000-1,375	4,444
mancozeb	Dithane M-45,Manzate 200	6,500-8,000	---
maneb	several	6,750	1,000+
MCPA	several	700-800	1,000+
MCPB sodium salt	several	680-700	1,000+
MCPP (mecroprop)	several	930	900
meltiuidide	Vistar	4,000+	4,000+
metalaxyl	Ridomil	669	3,100
methidathion	Supracide	20-65	25-400 640
methomyl	Lannate, Nudrin	17-26	2,400+ 5,880
methoxychlor	several	6,000	6,000

Common Name	Trade Name(s)	Oral LD-50 mg/kg	Dermal LD-50 mg/kg
methyl bromide	several	---	---
		Inhalation LC-50 (ppm)	200
methyl parathion	several	9-25	67
methyl thiophanate	Topsin-M	9,700	8,000+
metholachlor	Dual	2,780	10,000
metribuzin	Sencor,Lexone	1,937-1,986	---
mevinphos	Phosdrin	3.7-12	4.2-4.7 16-34 (rb)
MIT	Vorlex	305	---
monuraon TCA	Urox	2,300-6,700	1,000+
nabam	Dithane D-14	395	1,000+
naled	Dibrom	250-430	800 1,100 (rb)
napropamide	Devrinol	5,000+	4,640+ (rb)
naptalam	Alanap	8,200-8,500	---
nitrofen	TOK	1,470-2,840	5,000+
oryzalin	Surflan	10,000+	---
oxadiazon	Ronstar	8,000+	8,000+
oxycarboxin	Plantvax	2,000	16,000+
oxydemeton methyl	Metasystox-R	47-180	158-173
oxyfluorfen	Goal	5,000+	---
paradichlorobenzene	several	500-3,900	6,000+
paraquat	several	100-150	80-90
parathion	several	3-13	6.8-21
PCNB	Terraclor	1,750-12,000+	---
pebulate	Tillam	921-1,120	4,640+ (rb)
pendimithalin	Prowl	1,050-3,380	5,000+
penta (PCP)	several	50-270	105
permethrin	Ambush, Pounce	4,000+	2,000+
		Inhalation LC-50 (ppm):	23.5
phenmedipham	Betanal	8,000+	4,000+
phorate	Thimet	1.1-4	2.5-6.2
phosmet	Imidan	113-300 3,160 (rb)	1,550-2,000+
picloran	Tordon	8,200	4,000 (rb)
piperalin	Pipron	2,500	2,500+
prometon	Pramitol	490-2,980	2,500+
prometryn	Caparol	3,150-4,000+	2,500+
pronamide	Kerb	5,620-8,350	1,000 3,160 (rb)
propachlor	Ramrod	710-1,200	380
propazine	Milogard	4,000-5,000+	2,500+
propham	Chem-Hoe	3,700-9,000	4,000+
propoxur	Baygon	83-104	2,400+
pyrazon	Pyramin	620-3,600	2,500+
red squill	Red Squill	200-3,000[d]	---
SDMC	Vapam	820-1,260	800 2000-4640 (rb)
sethoxydim (proposed)	Poast	2,676-3,125	---
siduron	Tupersan	7,500+	5,500+
silvex (2,4,5-TP)	several	375-1,074	---
simazine	Princep	1,025-5,000+	8,160
sodium arsenite	several	10-50 (mammalian)	---

Common Name	Trade Name(s)	Oral LD-50 mg/kg	Dermal LD-50 mg/kg
sodium chlorate	several	1,200-5,000	---
sodium fluroacetate	1080	0.22	---
streptomycin	Agrimycin	9,000 (mouse)	600+
strychnine	several	1-30	---
2,4,5-T	several	300-500	1,500-2,000
2,3,6-TBA acids & salts	several	750-1,644	1,000
TCA	several	3,200-5,000	---
tebuthiuron	Spike	617-671	200+ (rb)
terbacil	Sinbar	5,000-7,000	5,000 (rb)
terbufos	Counter	4.5-9.0	29-1,425
terbutryn	Igran	2,400-2,500	10,200+
thiabendazole	Mertect	3,100	---
thiram	several	620-780	2,000+
toxaphene	several	49-90	780-1,075 145 (rb)
triademefon	Bayleron	568	1,000
triallate	Avadex BW	800-2,165	2225-4050 (rb)
trichlorfon	Dylox	450-630	2,000+
triclopyr	Garlon	713-2,830	---
trifluralin	Treflan	10,000	---
triohenyltin hydroxide	Du-Ter	108	5,000
vernolate	Vernam	1,710-1,780	4,640+ (rb)
vinclozolin	Ronilan	16,000	---
warfarin	several	58-323[e]	---
zinc phosphide	several	40-75.7	---
zineb	Dithane Z-78	5,000	2,500+
ziram	several	1,400	1,000+

[d]Values of 0.43 and 0.7 have reported.
[e]A value of 3.0 has been reported.