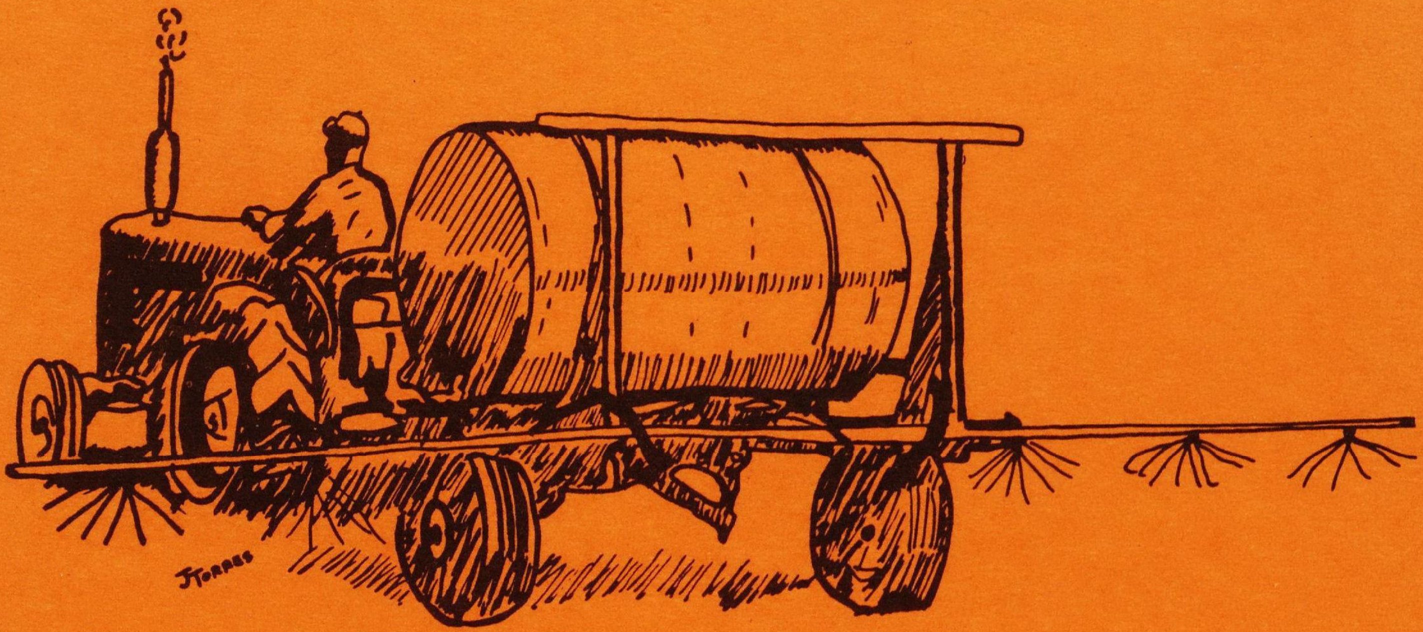
PRIVATE APPLICATOR TRAINING MANUAL

A HOME STUDY COURSE



U.S. ENVIRONMENTAL PROTECTION AGENCY

REGION VIII

#603

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ACKNOWLEDGMENTS

This manual was developed by the U.S. Environmental Protection Agency, Region VIII, Denver, Colorado. Cooperative Extension Service publications of the following universities were invaluable sources of information and material: University of California, Colorado State University, University of Illinois, Iowa State University, Montana State University, Michigan State University, Ohio State University, Purdue University, and the University of Wyoming. Publications of the United States Department of Agriculture and the Wisconsin Department of Agriculture also provided excellent and extremely useful information. Information contained in previously published EPA documents was also used in developing this manual.

SEPTEMBER 1983

INTRODUCTION

The amended Federal Insecticide, Fungicide and Rodenticide Act (FIFRA) contains a number of provisions designed to improve the control of pesticide use in terms of the environment and man while at the same time assuring that pesticides can continue to be available.

The amended FIFRA requires the U.S. Environmental Protection Agency (EPA) to classify all pesticide uses as either restricted use or general use. The FIFRA further requires that only certified applicators or applicators under the direct supervision of a certified applicator can apply pesticides classified for restricted use.

A pesticide product is designated as restricted use by EPA when it is felt that it may generally cause, without additional regulatory restrictions, unreasonable adverse effects on the environment, including injury to the applicator. Restricted use classification is an alternative to the cancellation of certain pesticides. The certification program is designed to ensure that users of restricted use pesticides are properly qualified to handle and apply these materials in a safe and efficient manner.

There is an increasing awareness among the general public concerning pesticides and problems associated with their use and misuse. Some of the concern is justified, some perhaps is not. Few would deny that pesticides are a vital tool for modern agriculture. Their continued use without further regulation, however, depends on their proper use.

This manual is designed to help ensure that private pesticide applicators use pesticides properly and that you, your neighbor and the environment are adequately protected. It is meant for your benefit and the benefit of agriculture. Improper use by a few is enough to deny the present benefits of pesticides to all.

This manual is not designed as an endorsement of pesticides. Indeed, other methods of control and particularly the implementation of integrated pest management (IPM) programs are strongly encouraged. Pesticides and their use are, however, the main concern of this manual.

This publication was prepared for private applicators who wish to be certified or recertified to use pesticides classified for restricted use. The information in this manual has been prepared to teach you:

1. Some facts about the various pests which may affect your farming operation,
2. A variety of methods which can be used to control pests,
3. What to look for on the pesticide label,
4. How to use pesticides so they will not harm you or the environment,
5. How to choose, use and care for application equipment,
6. Some basic calibration procedures,
7. Economic considerations regarding pest control, and
8. The Federal laws that apply to the use of pesticides.

Private applicators who successfully complete the questions accompanying this manual will be eligible for certification as defined by the amended FIFRA. This manual may be used by commercial applicators as a study guide but will not serve as a method for commercial applicator certification or recertification.

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CHAPTER 1

LAWS AND REGULATIONS

FIFRA

The Federal Insecticide, Fungicide, and Rodenticide Act (FIFRA) requires the U. S. Environmental Protection Agency (EPA) to regulate pesticides. The FIFRA provides that all pesticide uses be classified for restricted use or general use. Pesticide products are classified by use and not necessarily by the active ingredient. A pesticide may contain 5 percent of a certain active ingredient and be classified for general use while another pesticide has 25 percent of the same active ingredient and is classified for restricted use. Another example is that two pesticides may contain the same percentage of the same active ingredient and be classified differently. An example is when the restricted use product is registered for use on irrigation ditch banks while the other product is for agricultural crop land and is classified for general use.

In addition to requiring that all pesticide uses be classified for restricted or general use, the FIFRA requires that only certified applicators or applicators under the direct supervision of a certified applicator can apply restricted use pesticides. There is an individual certification program for each state. In most states the state department of agriculture is conducting the program. However, there are some states in which EPA is administering the program.

The FIFRA defines two types of pesticide applicators: private and commercial. A private applicator is a person who uses or supervises the use of restricted use pesticides in the production of agricultural commodities on land owned or rented by him or his employer. A private applicator can apply restricted use pesticides on the property of another person if applied without compensation other than the trading of personal services between the producers of agricultural commodities. A commercial applicator is any person who uses or supervises the use of restricted use pesticides and is not a private applicator. Examples of commercial applicators include but are not limited to: ditch company employees, golf course workers, grain elevator operators, applicators employed by government agencies, and applicators who apply pesticides for hire.

An applicator may apply a restricted use pesticide without being certified if he is under the direct supervision of a certified applicator. "Under the direct supervision of a certified applicator" is defined as follows: "Unless otherwise prescribed by its labeling, a pesticide shall be considered to be applied under the direct supervision of a certified applicator if it is applied by a competent person acting under the instructions and control of a certified applicator who is available if and when needed, even though such certified applicator is not physically present at the time and place the pesticide is applied". If a restricted use pesticide is applied by an uncertified applicator under the direct supervision of a certified applicator, both the actual applicator and the individual supervising the application are legally responsible for its proper application. If a violation occurs, both individuals could be subject to civil or criminal fines under the amended FIFRA or various state pesticide laws.

EPA is also responsible for regulating the amount or residue of a pesticide which can remain in or on raw farm products. 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 consumption. 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 feed product. Using pounds as a measure, 50 ppm would be 50 pounds of pesticides in 999,950 pounds of farm product. The total pounds of pesticides (50 lbs.) plus the total pounds of farm product (999,950 lbs.) is one million pounds.

If too much residue is found in or on a farm or feed product, the product may be seized or condemned. In order to help an applicator avoid an illegal residue, pesticide labels provide instructions on proper application rates and the number of days the pesticide may be applied prior to harvest. By reading the pesticide label you can help prevent illegal residues and avoid possible loss of your crop.

The FIFRA prohibits using a pesticide in a manner inconsistent with its labeling, in other words "misusing" a pesticide. It is also illegal to dispose of any pesticide container or pesticide rinsate by a means other than those stated on the label; or to detach, alter, deface or destroy any part of the labeling. However, the FIFRA permits applying pesticides at any dosage, concentration or frequency <u>less</u> than that specified on the label. A pesticide may also be used to control any target pest not specified on the labeling if the application is to the crop, animal or site specified on the labeling and is not prohibited by the labeling. It is also not considered misuse to employ any method of application not prohibited by the labeling or to apply a pesticide in combination with another pesticide or fertilizer if such a mixture is not prohibited by the labeling.

EPA may assess penalties for violations of the FIFRA. A private applicator who violates any of the provisions of the FIFRA may be asessed a civil penalty up to $1,000 for each offense. (EPA will send a private applicator a warning letter for the first violation.) Criminal offenses (knowing violations) can result in private applicators receiving a $1,000 fine and/or 30 days in prison.

Commercial applicators can be assessed a $5,000 civil penalty for each violation or a $25,000 fine and/or one year in prison for a criminal violation. EPA is not required to send a commercial applicator a warning letter prior to assessing a fine.

CHAPTER 2

LABELS AND LABELING

There are two exhibits which will be used for this chapter. Exhibit 1 is a front panel of a sample label and Exhibit 2 is the back panel of a sample label. Exhibits 1 and 2 are located at the end of this Chapter.

The printed material on a pesticide label and labeling (literature which accompanies the product) has all of the necessary information and instructions for the effective and safe use of the pesticide. The FIFRA requires each pesticide label to include the following:

1. Brand name, common name, and chemical name,
2. Use classification,
3. Ingredient statement,
4. Registered uses,
5. Directions for use,
6. Safety information, signal words and precautions,
7. Net contents,
8. Name and address of manufacturer or registrant,
9. EPA registration number and the establishment number.

The brand name is the producer's or formulator's proprietary name for the pesticide. The common name is the generic name accepted for the active ingredient of the pesticide product regardless of the brand name. The chemical name of the pesticide is generally found in the ingredient statement and lists the chemical for which the pesticide is designed.

Pesticides are classified for general use or restricted use and each pesticide label should indicate the classification of that pesticide. Some pesticides have not been classified and will not have a classification statement on the label. However, all pesticides which have been classified for restricted use must have the following statement on the label.

"For retail sale to and use only by certified applicators or persons under their direct supervision and only for those uses covered by the certified applicator's certification."

The pesticide label only lists the uses for which the pesticide is registered. These are the legal uses for the product. It is illegal to use a pesticide in a manner inconsistent with the label's registered uses. There are a few exceptions which were discussed in Chapter 1.

The directions for use give specific instructions for using the product properly and tell you when to use the pesticide, how to apply the particular formulation, where to apply it and dosage rates. Directions for use also give you information on the number of applications that can be made over a given period of time and the length of time and days that you must allow between the last application and harvest or slaughter.

On some pesticide labels you will find a range for the suggested dosage. For example, the label may suggest 1/2 to 2 pints of active ingredient per acre. In this case you should use the lowest rate that will give the best control. If you have questions or doubts, be sure to contact your local county extension agent or agricultural consultant for suggested rates that work best in your area.

The label contains the information you need to use the product safely. Certain signal words are required on every pesticide label. Depending on the hazard to the user of the particular product, these words are DANGER-POISON and the skull and crossbones (all in red), WARNING or CAUTION. In addition, the label must carry the statement KEEP OUT OF THE REACH OF CHILDREN. The signal word required depends upon the toxicity and potential hazard of the active ingredient and also the formulation of the pesticide. The following chart gives the hazard indication associated with the signal words and the estimated amounts required to kill a man when the pesticide is taken by mouth.

Signal Words	Toxicity	Approximate amount needed to kill the average person
DANGER	Highly Toxic	A taste to a teaspoonful
WARNING	Moderately Toxic	A teaspoonful to a tablespoonful
CAUTION	Low order of toxicity	An ounce to more than a pint

The FIFRA requires the name of the manufacturer or distributor on the label so you will know who made or sold the product. Every pesticide registered with EPA must have an EPA registration number. This number must appear on the pesticide label. The EPA establishment number identifies the factory (plant) that made the product. It does not have to appear on the label but must be somewhere on each pesticide container.

EXHIBIT 1 - SAMPLE ONLY

LOW-VOLUME 2 LB.

ACTIVE INGREDIENT:		
Isooctyl Ester of 2,4-Dichlorophenoxyacetic Acid*		46.4%
INERT INGREDIENTS:		53.6%
	TOTAL	100.0%

*Equivalent to 2,4-Dichlorophenoxyacetic Acid 34.3%
Contains 2.3 Pounds of 2,4-D Acid Equivalent Per Gallon

CAUTION
KEEP OUT OF THE REACH OF CHILDREN
SEE SIDE PANELS FOR ADDITIONAL CAUTIONS

Harmful if swallowed.
May cause skin irritation.
Avoid contact with eyes, skin and clothing. If contact with eyes occurs, flush with plenty of water.
DO NOT store near fertilizers, seeds, insecticides or fungicides.
DO NOT contaminate irrigation ditches or water used for domestic purposes.
Use care to avoid spray drift to 2,4-D susceptible plants such as tomatoes, flowers, grapes, fruit trees and ornamentals. Trace amounts of spray drift may cause severe injury to both growing and dormant plants. Coarse sprays are less likely to drift. Spray only on calm days using low pressure and lowered boom. VAPORS may injure 2,4-D sensitive plants in the vicinty.
Flush sprayer out on suitable non-crop area after use. DO NOT use the same spray equipment for applying other materials to plants as injury will result.
DO NOT reuse empty container. Return to drum reconditioner or destroy by perforating, crushing and burying or disposing of in a safe place.
This product is toxic to fish. Keep out of lakes, ponds or streams. DO NOT contaminate water by cleaning of equipment or disposal of wastes. Apply only as directed on this label.

EPA REG. NO. 000-00-AA   EPA EST. NO. 00-AA-1

MANUFACTURED FOR: ABC CHEMICAL COMPANY
345 MAIN STREET, SNOWHILL, MAINE 00000

READ ENTIRE LABEL BEFORE USING THIS PRODUCT
GENERAL INFORMATION

LOW-VOLUME 2 LB. is a selective herbicide for control of many broadleaf weeds in certain crops, around buildings, along fence rows and pastures. A partial list of weeds controlled by LOW-VOLUME 2 LB. is shown below:

Bindweed	Lambsquarter	Plaintain
Cocklebur	Mustards	Ragweed
Dandelion	Morningglory	Thistles
Knotweed	Pigweed	Wild Radish

NOTE: Local conditions, crop varieties, and application regulations vary and may affect use of this herbicide. Consult local agricultural experiment station or extension agent and state regulatory agencies for recommendations in your area.

Aerial application may be of use for control of weeds on certain crops where there would be no danger of drift to susceptible crops. Applications should only be made by applicators experienced in the use of 2,4-D formulations. Regulations governing aerial application of herbicides are in effect in many states. Consult local regulatory agencies concerning requirements before making applications.

DIRECTIONS FOR USE

PREPARATION OF THE SPRAY: Fill the spray tank with half the required amount of water. Then add the recommended amount of LOW-VOLUME 2 LB. and continue filling the spray tank with balance of water. Keep agitator running when filling spray tank and during spray operations. The amount of water required for low-volume applications may vary from 5 to 25 gallons per acre. For high volume applications, 100 gallons or more of water will be needed for good coverage. In any case, use the same amount of 2,4-D recommended per acre.

TIME OF APPLICATION: Best results are obtained when LOW-VOLUME 2 LB. is used on young weeds that are actively growing. Applications of lower rates to susceptible annual weeds usually will be satisfactory, but for perennial weeds and other conditions, such as in very dry areas where kill is difficult, use higher rates.

SMALL GRAINS (Wheat, Barley, Rye): Apply LOW-VOLUME 2 LB. in sufficient water for uniform coverage on small grains when fully tillered or stooled (4 to 8 inches tall), but before head emrges from the "boot". Crop injury may result if applied earlier than "tiller" or later than "boot" stage. DO NOT use on grain undersown with legumes, such as alfalfa or clovers, except where some legume injury can be tolerated. DO NOT graze or feed forage from treated fields within 2 weeks after treatment.

LAWNS, GOLF COURSES AND SIMILAR TURF: Apply 2 pints of LOW-VOLUME 2 LB. per acre in sufficient water to provide uniform coverage. DO NOT apply to newly seeded lawns until grasses become well established. Injury may result if applied to bentgrass, St. Augustinegrass and clovers in lawns.

AMOUNT OF LOW-VOLUME 2 LB. PER ACRE

CROP (See detailed directions)	AMOUNT (Average conditions)
Small Grains - Annual Weeds	1/2 to 1 pint
Small Grains - Perennial Weeds	1 pint
Lawns, Golf Courses & Turf	2 pints

WOODY PLANT CONTROL: To control 2,4-D susceptible woody plants such as alder, buckbrush, elderberry and willow on non-crop land and waste areas, use 2 to 3 quarts of LOW-VOLUME 2 LB. in 100 gallons of water. Wet thoroughly all parts of the plants, including foliage and stems, to the point of run-off. Higher volumes are necessary where the brush is very dense and over 6 to 8 feet high. Applications are more effective when applied to actively growing plants. DO NOT treat during periods of severe drought or in early fall when leaves have lost their healthy green color. Hard to kill species may need retreatment the following season.

GENERAL WEED CONTROL: Along fence rows, drainage ditch banks, roadsides, industrial sites, around farm buildings and similar areas. Use 1 to 2 quarts of LOW-VOLUME 2 LB. in 100 gallons of water per acre. Thoroughly wet all foliage to run-off.

CHAPTER 3

PESTICIDE SAFETY

Pesticides used to control the numerous pests that affect the production of our food and fiber are toxic. The danger of a pesticide depends on a great many things. One of the most important factors is the pesticide's relative toxicity to man and pests.

A pesticide can cause severe illness or even death if it is misused. Every user must be aware of the hazards to himself, to other people and the surrounding environment. The user is responsible to help prevent accidents with pesticides by following all directions on the pesticide label.

Choosing the correct pesticide to use is one of the most important segments of carrying out an effective pest control program. The pesticide you choose will be instrumental in the effectiveness of your control program. It will have a direct bearing on the hazards to which you as well as other persons and the environment are subjected. Actually a potential hazard may be present the moment you purchase a pesticide. The selection of type of pesticide, the formulation to be used and even the container type may be factors contributing to a pesticide accident.

Pesticides are designed to be poisonous to kill the pest for which they are used against. There are, however, great ranges in the level of toxicity among different pesticides. It is important that you have a broad, general knowledge of the relative toxicity of at least the most common pesticides used in your particular area.

Exhibits 3 and 4 at the end of this chapter provide information on the relative toxicity of some of the more common pesticides. The toxicity of a pesticide is the capacity for that pesticide to produce injury. It is expressed in terms of the amount of the pesticide per unit of weight of a test animal needed to kill 50 percent of the population tested with a single dose. This figure is called the LD50 for that pesticide. The LD50 is expressed as one part of pesticide per one million parts of body weight of the test animal. The acute toxicity of a pesticide is how poisonous it is to an animal (or man) after a single exposure (single dose). (An LD50 may be expressed as dermal (skin), oral (mouth) or inhalation (breathing)).

It is important to realize that the toxicity rating for any pesticide is only approximate. The toxicity ratings on test animals can only be used as an indication of relative toxicity to man. Always remember the lower the LD50 value the more toxic the pesticide.

Pesticides can enter the body by three routes: oral, dermal, and inhalation.

Oral - Pesticides can enter the body through the mouth. Accidental splashing of liquid or blowing of dusts or granules can enter the mouth and cause poisoning. Smoking or eating food with contaminated hands, allowing food to be exposed to sprays or dusts and blowing on nozzles to clear orificies also can cause pesticide ingestion. The most frequent cases of accidental ingestion are those in which pesticides have been put in unlabeled bottles or food containers or are stored where children can consume them.

Dermal - Pesticides can enter the body by absorption through the skin. It is the main route of entry when liquid sprays and emulsifiable concentrate formulations are used.

The degree of skin absorption depends upon the type and formulation of pesticide and the part of the body with which the pesticide comes in contact. Any break in the skin can enhance the entry of a pesticide into the blood stream. Burns, dermatitis and eczema also may enhance the absorption of a pesticide.

Inhalation - Pesticides may also enter the body through the respiratory tract. Pesticides in the form of dusts, spray mists and vapors are drawn into the lungs rapidly and completely. Respiratory hazards are greater when low volume/high pressure equipment is used as opposed to conventional application equipment that produces large droplets. The higher the application pressure the more likely the chance of inhaling pesticides. Pesticides inhaled in sufficient quantities may cause serious damage or irritation to nose, throat and lung tissues or possibly death.

A pesticide that is highly toxic may be less hazardous to the public than a pesticide of relatively low toxicity. The hazard of a pesticide is the probability that injury or environmental damage will result from the use of the pesticide. The relative hazard of a pesticide is reduced when the pesticide is used properly. This includes application only to the sites listed on the label, use of proper application and safety equipment and applying only the dosage listed on the registered label. If a pesticide of relatively low toxicity is used in a careless manner it has the potential to cause more injury or environmental damage than a highly toxic pesticide used properly.

Mixing Pesticides

Some pesticides are applied just as purchased and need no mixing. Other pesticides need mixing with a carrier, water being the most common. The following procedures should be followed when handling and mixing pesticides:

a. Open containers cautiously and pour carefully to avoid spilling,

b. Mix and prepare in the open or in well ventilated places. In close quarters highly toxic pesticides may cause poisoning through inhalation. If volatile, they can cause fires or explosions.
c. Make sure there is no chance of food, feed or water contamination,
d. Allow no children or pets to be present,
e. Use special containers reserved for or designed for mixing. Do not use food or beverage containers,
f. Do not mix in concentrations higher than recommended,
g. Measure accurately to help avoid injury or environmental damage,
h. Use protective equipment and clothing if required by the pesticide label. Avoid inhaling fumes, mists or dusts,
i. Avoid spilling concentrates on the skin or clothes and keep them away from the eyes, mouth and nose. If any is spilled, wash it off the skin with soap/detergent and water and change clothes immediately. Launder contaminated clothing separate from other clothing before wearing it again,
j. Do not smoke, eat or drink when mixing pesticides,
k. Use check valve in suction filler hoses to prevent resiphoning into water sources. Do not allow tank to overflow. Never siphon pesticides or pesticide mixtures with your mouth,
l. Empty pesticide containers thoroughly and rinse them three times before disposing of them. Rinsate should be put into the spray tank,
m. Make sure when mixing pesticides together that they are physically and chemically compatible,
n. Adjuvants may be needed to help the pesticide do a better job.

Applying Pesticides

The following procedures should be considered when applying pesticides:

a. If the pesticide label requires protective clothing, make sure you have and use the proper clothing,
b. Do not apply dosages greater than those listed on the pesticide label,
c. Observe the danger of drift that may contaminate other areas,
d. Know what pesticides may be phytotoxic (chemically toxic) to plants,
e. Apply the pesticide only to crops or animals listed on the pesticide label,
f. Time your application to prevent illegal pesticide residues on food, feed or forage crops. Allow the prescribed number of days between the last application and harvest,
g. Guard against run-off or drift that may contaminate water supplies, fish-bearing waters or wildlife habitat,
h. Do not smoke, drink or eat when applying pesticides,
i. If you feel ill while applying pesticides, stop work at once and get medical attention.
j. Always be sure to observe all re-entry precautions and restrictions.

Protective Equipment

The best insurance against poisoning by pesticides is to protect the routes by which pesticides enter the body: oral, dermal and inhalation. Gooa protection requires the routine use of respiratory protective devices, dermal protective garments and sound practices of personal hygiene.

There is a wide variety of protective equipment available. The proper selection and use of this equipment will depend on what is required by the pesticide label and the type of work environment.

Dermal Protective Equipment

Impermeable Clothing - This type of clothing is made from rubber neoprene or polyvinyl coatings on cloth fabrics. The coating material serves as a barrier against liquid penetration. Clothing should be light enough to be comfortable but heavy enough to be durable. Additional comfort can be gained if a light color is selected.

Heavy Grade Cloth Coverings - Heavy grade cotton, one piece coveralls can be used in most spray operations if spills from concentrated material are not anticipated. They should be changed when noticeably wet, and washed after each day's use in a strong detergent.

Head and Neck Covering - Impermeable (waterproof) head gear should be worn to protect the head, neck and hair from pesticide drift. Broad brimmed waterproof rainhats and hoods will protect the ears and neck from downward drift. Head gear should be washed frequently with water and detergent. Under no condition should hats of felt or other absorbent materials be worn when applying pesticides. Sweat bands should not be used since they can absorb the pesticide and provide a continuous source of pesticide exposure.

Gloves - Unlined, impermeable gloves should be worn when using pesticides. Heavyweight gloves, although more durable, should be avoided because they restrict freedom of movement and are more likely to be removed when working around spray equipment. Lightweight gloves should be checked frequently for pinholes and breaks. Select gloves that are durable but which provide reasonable movement of fingers.

Goggles - Protective shields or goggles should be used when there is any danger of pesticides coming in contact with the eyes. Eye protection is most often needed when measuring or mixing concentrated pesticides or when spray or dust might be a problem. Goggles and eye shields should be kept clean at all times.

Boots - Waterproof footwear, generally rubberized boots, should be worn when making any type of pesticide application. Never wear pant legs inside of your boots. This may cause pesticides to run down the fabric and into your of boots.

Respiratory Protective Equipment

A respiratory device should be worn any time you might inhale toxic pesticides. A respirator should be worn when you may be exposed to a highly toxic pesticide or if you are working in an enclosed area. Check the information on the label for the type of respirator to use.

Chemical Cartridge Type - The cartridge type respirator is usually a half-face mask that covers only the nose and mouth. Air is filtered and toxic fumes and vapors are absorbed by one or two cartridges of activated charcoal. This respirator is usually worn with goggles to give protection to the eyes.

Gas Mask Type - Gas mask respirators cover the entire face and protect your eyes as well as your nose and mouth. Face pieces are made to hold a container directly (chin style) or are connected to a canister with a flexible hose (chest or back style). This type contains filters with more absorbing material to cleanse the air than the cartridge type. Gas mask type respirators may have a self-contained oxygen supply. Self-contained gas masks must be used when an applicator may be exposed to high concentrations of highly toxic pesticides in enclosed areas.

Care and Maintenance of Respirator Equipment - Every applicator using a respirator should be knowlegdeable on proper selection, use and maintenance. A good face piece fit is essential for effective protection with respirators and gas masks.

The proper maintenance and care of respirators should include inspections for defects, cleaning and disinfecting, repair and storage. They should be inspected routinely before and after each use. An inspection check should include tightness of connections and condition of the face piece, head bands, valves, connecting tube and canister. Respiratory devices should be cleaned after each day's use. Prior to cleaning, any filter, cartridge or canister should be removed. The face piece and breathing tube should be washed with warm soapy water, rinsed in fresh water to remove all traces of soap, and sanitized if necessary. Respirators should be air dried in a clean area separate from pesticide storage or other possible pesticide sources.

The respirator device, filters and cartridges should be stored, preferably in a plastic bag or container, in a clean, cool, and dry place. When using a respirator, the cloth filter should be changed twice a day or more often if breathing becomes difficult. Cartridges should be changed after eight hours of actual use or more often if an odor of the pesticide is detected.

Personal Clean Up

The importance of personal cleanliness and the proper care of clothing and protective equipment cannot be over emphasized. Use common sense whenever you're handling pesticides. Always wash your hands and face thoroughly before eating, drinking or smoking. If clothes become contaminated, change them immediately and shower if necessary. Destroy clothing if highly toxic concentrates are spilled or splashed on them. Adequate cleaning of clothing contaminated with concentrates is virtually impossible.

Wash all protective equipment thoroughly with warm water and detergent after each use. Dry it completely and store in a secure area which is clean and dry and away from all pesticides.

Remove clothing as soon as possible after you have finished working with pesticides. All clothing must be washed thoroughly before you wear it again. Never store or wash contaminated clothing with the family laundery and never wash it in streams or ponds. The person washing work clothes should be made aware of the potential hazards. Clothing should be washed in detergent and hot water. Particular attention should be paid to belts and shoes which are often not considered part of a clothing change and may therefore be a source of long term (chronic) exposure. Special care should be taken when wearing leather belts and shoes since leather contaminated with pesticides cannot be cleaned.

Take a shower at the end of each work day. Wash thoroughly with a detergent, paying close attention to hair and fingernails. Put on a complete change of clothing, including underwear.

Storage and Transportation of Pesticides

Always read the label for correct storage procedures. Pesticides should always be stored in their original, labeled container in a dry, locked, well ventilated area where humans, livestock and pets cannot come in contact with them. Stored containers should be periodically checked for corrosion, leaks, breaks and tears.

Storage facilities should be located away from populated areas and be well marked to inform people of the hazards that exist. The storage structure should be insulated and heated to keep pesticides from freezing and overheating. All doors should be kept locked whenever the facility is not in use.

To reduce fire hazards, the structure should be constructed of fire resistant material and fire fighting equipment should be made easily available. To help fire fighting procedures, an inventory should be kept of all pesticides stored.

The importance of preventing the spillage of toxic pesticides during transportation cannot be overemphasized. Anyone transporting any chemical should place it in the back of a pickup or truck with sufficient sides and tailgate to prevent containers from rolling out. Fasten down all containers to prevent them from tipping.

Spillage of a pesticide in transport must be considered an emergency requiring prompt cleanup, protection of human health, safe disposal of damaged containers and special care or disposal of damaged cargo.

Whenever a spill occcurs in transporting pesticides, acquire competent help. The welfare of the people directly involved and the general public must be protected.

All pesticide containers should be checked for damage and leaks before transporting. The container label should be checked before transporting to determine if special instructions are given for movement of the container. Do not transport pesticides in the same compartment with food, feed, seed or fertilizer.

Disposal of 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. 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 disposal concerns facing applicators, adherence to a few basic guidelines can greatly reduce potential problems. All pesticide wastes must be handled and disposed of properly.

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 with water (or other 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. Unless otherwise provided for by label directions, puncture and flatten the can so it cannot be reused.

Putting the rinsate into the spray tank serves the following purposes: rinsates are used in the spray mixture itself and are not haphazardly dumped on the ground and you get the most out of your pesticide dollar. If rinsates are not put into the spray tank, you must: (1) use them subsequently on a crop or other site listed on the label and in accordance with label directions, (2) use them to mix future solutions of the same pesticide or (3) dispose of them in accordance with all label directions.

Safely Dispose of Rinsed Containers - Farmers can legally bury triple-rinsed containers on their own land. This must be done conscientiously while taking into account all appropriate precautions. Be careful not to bury them near wetlands, streams, ponds or other surface waters. Under no circumstances should rinsed containers be carelessly discarded.

Some local landfills are authorized to accept triple-rinsed containers. In order to determine which landfills will accept these containers, you should check with your local health department or county extension agent.

Empty pesticide bags may be burned if local air pollution regulations permit. When burning bags, make sure that you do not come into contact with the smoke. The smoke from the bags could be a source of pesticide poisoning.

Recycle Empty Containers - A number of pesticide dealers and manufacturers will accept pesticide containers for reuse. You should check with your local pesticide dealer or salesman to find out which companies will accept used containers.

<u>Symptoms and Signs of Pesticide Poisoning</u>

You should know what kinds of sickness are caused by the pesticides you use. You should also know the conditions under which each one may make you sick. There are two kinds of clues to pesticide poisoning. Some are feelings that only the person who has been poisoned can notice such as nausea or headache. These are called "symptoms". Others, like vomiting, also can be noticed by someone else. These are "signs". So you should know what your own feelings might mean and what signs of poisoning to look for in others who may have been exposed to a pesticide.

All pesticides in the same chemical group cause the same kind of sickness. This sickness may be mild or severe depending on the pesticide and the amount absorbed. The pattern of illness caused by one type of pesticide is always the same. Having some of the signs and symptoms does not always mean you have been poisoned. Headache and a feeling of being unwell, for example, may signal the start of many kinds of illness. It is the pattern of symptoms that makes it possible to tell one kind of sickness from another.

Organophosphates - These pesticides injure the nervous system. The signs and symptoms go through stages. They normally occur in this order:

Mild Poisoning
- fatigue,
- headache,
- dizziness,

blurred vision,
too much sweating and salivation,
nausea and vomiting,
stomach cramps or diarrhea.

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

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

Illness may be delayed a few hours. But if signs or symptoms start more than 12 hours after you were exposed to the pesticide, you probably have some other illness. Check with your doctor to be sure.

Carbamates - The only carbamates likely to make you ill act almost like organophosphates. They produce the same signs and symptoms if you are poisoned by them. However, the injury they cause can be treated more easily by a doctor. For this reason, most carbamates are safer than organophosphates.

Organochlorines - Not many applicators have been poisoned by organochlorines (chlorinated hydrocarbons). Early signs and symptoms of poisoning include:
headache,
nausea,
vomiting,
general discomfort, and
dizziness.

With more severe poisoning, convulsions follow. They may even appear without warning. Coma may follow the convulsions. The person may also be unusually excited or irritable.

Nitrophenols and Pentachlorophenol - The signs and symptoms of skin exposure include:
redness,
burning, and
blisters.

The signs and symptoms of poisoning include:
headache,
nausea,
gastric distress,
restlessness,
hot feeling,
flushed skin,
sweating,
deep and fast breathing,
fast beating of the heart,
fever,
ashen color,
collapse, and
coma.

Severe poisoning usually runs a rapid course. Within 24 to 48 hours one usually dies or is almost well.

Fumigants and Solvents - Too much exposure to the these compounds may make a person seem drunk. The signs and symptoms are:
poor coordination,
slurring words,
confusion, and
sleepiness.

Repeated exposure to the fumigant methyl bromide has caused permanent internal injury without early signs or symptoms of poisoning. You can absorb a fatal dose of it before symptoms appear.

Inorganic Pesticides - Large single doses of most inorganic pesticides cause vomiting and stomach pain. The signs and symptoms depend on the mineral from which the pesticide is made. If you will be using an inorganic pesticide, you should consult your local doctor for signs and symptoms of poisoning of the particular pesticide(s) you are using.

Plant-Derived Pesticides - Some plant-derived pesticides are very toxic. Technical pryethrum may cause allergic reactions. Some rotenone dusts irritate the respiratory tract. Nicotine is a fast acting nerve poison about as dangerous as parathion. Some other plant-derived pesticides are strychnine and red squill.

First Aid For Pesticide Poisoning

Federal regulations require that where a pesticide hazard exists, appropriate first aid statements must appear on the pesticide label. Those pesticides which are considered highly toxic on the basis of oral, inhalation or dermal toxicity must have a statement of practical treatment on the label. Practical treatment statements on the label are your first source of information. You should also be thoroughly familiar with basic first aid procedures. This knowledge could help prevent serious injury or death.

Always remember that first aid procedures are just that - they are your first response to pesticide exposure. They are not a substitute for professional medical help. You should be aware of the importance of knowing when professional medical help is needed. If in doubt, seek medical attention.

Your response to a pesticide poisoning obviously depends to some extent on whether you or someone else is the victim. The same basic first aid principles must be followed in either case. If you are exposed to a pesticide when you are working alone, remain calm. The serious effects of pesticides are generally not instantaneous so you will have some time to respond properly. If you act intelligently, you will minimize any adverse effects and you may save your life.

In the event of an accident, you should immediately begin proper first aid procedures and get help. If you have been exposed to a highly toxic pesticide or if you begin to feel ill, you must get to a doctor. If you are with someone else who is exposed to a pesticide, immediately begin first aid treatment or assist the victim in any way you can. Even where the pesticide is less toxic it may be advisable to seek medical attention, particularly if you were exposed to a high amount of the pesticide. If you swallow a pesticide or get some in your eyes, always see a doctor immediately. Have someone take you to the doctor. Make sure that the label or the labeled container is given to the doctor. Do not take the container in the passenger compartment with you. In order to help prevent serious injury or death, you should work with someone else when mixing or applying pesticides.

General First Aid Instructions

If oral or dermal exposure has occurred, your first objective is usually to dilute the pesticide as quickly and as effectively as possible. You should have a supply of water readily available when you're working with pesticides. You can use any source of fairly clean water, including water from lakes, streams, ponds, watering troughs, etc.

If inhalation exposure has occurred, get to fresh air immediately. If you're with someone who has been exposed to a pesticide and if his or her breathing has stopped, give mouth-to-mouth resuscitation. If you work with pesticides very often, you should learn how to give mouth-to-mouth respiration. Never try to give any liquids or medication orally to an unconscious person.

Specific First Aid Instructions

Specific first aid treatment varies according to the type of exposure. You should become thoroughly familiar with all of the appropriate procedures. They should be learned prior to the time of an accident since you probably won't have the time or the opportunity to look them up if you ever need them.

Dermal Exposure

Remove clothing if it has been contaminated,
Drench skin with water,
Wash thoroughly including hair if necessary. Detergent and commercial cleansers are better than soap,
Rinse thoroughly. Use rubbing alcohol if it is readily available rather than water,
Wash again and rinse,
Dry and wrap in a blanket,
Where chemical burns of the skin have occurred, cover the area loosely with a clean, soft cloth. Avoid the use of ointments, greases, powders and other medications.

Inhalation Exposure

Get to fresh air immediately,
If you're with someone who has been poisoned, carry the victim to fresh air immediately,
Do not attempt to rescue someone who has been poisoned in an enclosed area if you do not have the proper respiratory equipment,
Loosen all tight clothing,
If breathing has stopped, give artificial respiration,
Victim should remain as quiet as possible,
Prevent chilling (wrap in blankets but don't overheat),
If you are with a victim who is having convulsions, watch his breathing and protect him from falling and striking his head. Keep his chin up so his air passages will remain free for breathing,
Do not give alcohol to the victim.

Eye Exposure

Hold eyelids open and wash eyes with a gentle stream of clean running water. Use large amounts of water. Do so immediately, delay of even a few seconds greatly increases the possiblity of permanant injury, continue to wash for 15 minutes or more,
Do not use medications in the wash water.

Oral Exposure

If a pesticide has gotten into your mouth but has not been swallowed, rinse your mouth with large amounts of water.

If a pesticide has been swallowed, the most important consideration is whether or not to induce vomiting. The decision must be made quickly and correctly. Where specific instructions are given on the pesticide label, always follow them. Beyond that NEVER induce vomiting if:

a. the victim is unconscious or is having convulsions,
b. the pesticide is corrosive. (A corrosive substance is any material such as a strong acid or alkali (base) which causes chemical destruction of living tissue. Poisoning symptoms include severe pain and a burning sensation in the mouth or throat.)

In attempting to induce vomiting it is important to use safe and effective procedures. Vomiting should be induced with two tablespoons (one ounce) of Syrup of Ipecac and two glasses of water for an adult or one tablespoon (one-half ounce) of Syrup of Ipecac and one glass of water for a child. If Syrup of Ipecac is not available, induce vomiting by drinking 1 or 2 glasses of water then touching the back of the throat with your finger. Salt water should not be used to induce vomiting. The victim should be lying face down or kneeling while vomiting. This will prevent the victim from swallowing the vomitus which could cause further damage. Do not spend a lot of time attempting to induce vomiting. Get to a hospital as soon as possible.

Where the label identifies specific antidotes, this information is intended for use by a doctor. Antidotes should not be administered except under the direction of a physician or other medical personnel. Taken improperly, antidotes can be more harmful than the pesticide itself.

The name, address and telephone number of the physician, clinic or hospital emergency room that will provide care in the event of an accident should be clearly posted at all work sites.

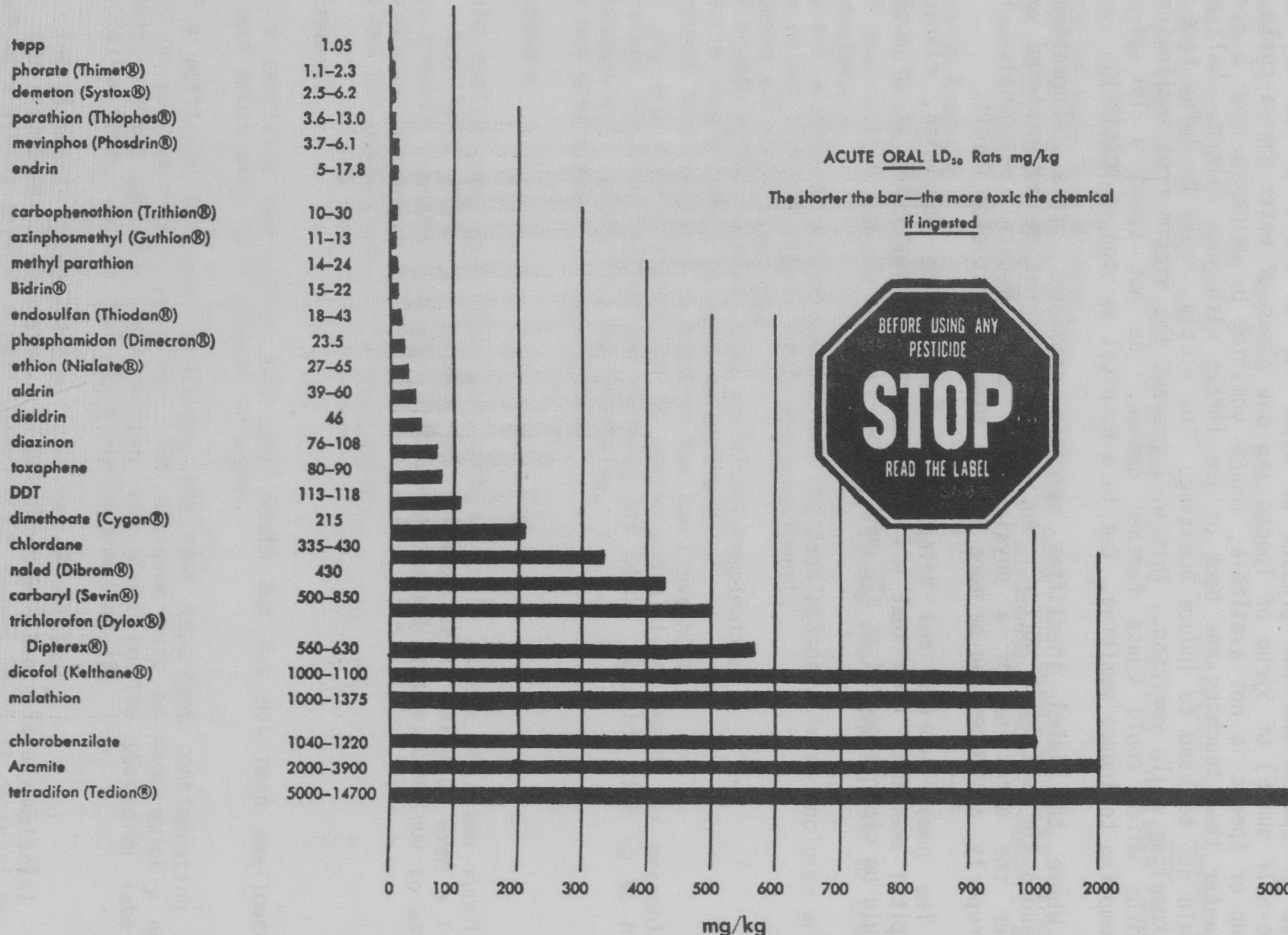

ACUTE ORAL LD50 Rats mg/kg
The shorter the bar—the more toxic the chemical if ingested
BEFORE USING ANY PESTICIDE
STOP
READ THE LABEL
tepp 1.05
phorate (Thimet®) 1.1–2.3
demeton (Systox®) 2.5–6.2
parathion (Thiophos®) 3.6–13.0
mevinphos (Phosdrin®) 3.7–6.1
endrin 5–17.8
carbophenothion (Trithion®) 10–30
azinphosmethyl (Guthion®) 11–13
methyl parathion 14–24
Bidrin® 15–22
endosulfan (Thiodan®) 18–43
phosphamidon (Dimecron®) 23.5
ethion (Nialate®) 27–65
aldrin 39–60
dieldrin 46
diazinon 76–108
toxaphene 80–90
DDT 113–118
dimethoate (Cygon®) 215
chlordane 335–430
naled (Dibrom®) 430
carbaryl (Sevin®) 500–850
trichlorofon (Dylox®)
Dipterex®) 560–630
dicofol (Kelthane®) 1000–1100
malathion 1000–1375
chlorobenzilate 1040–1220
Aramite 2000–3900
tetradifon (Tedion®) 5000–14700
0 100 200 300 400 500 600 700 800 900 1000 2000 5000
mg/kg

EXHIBIT 3

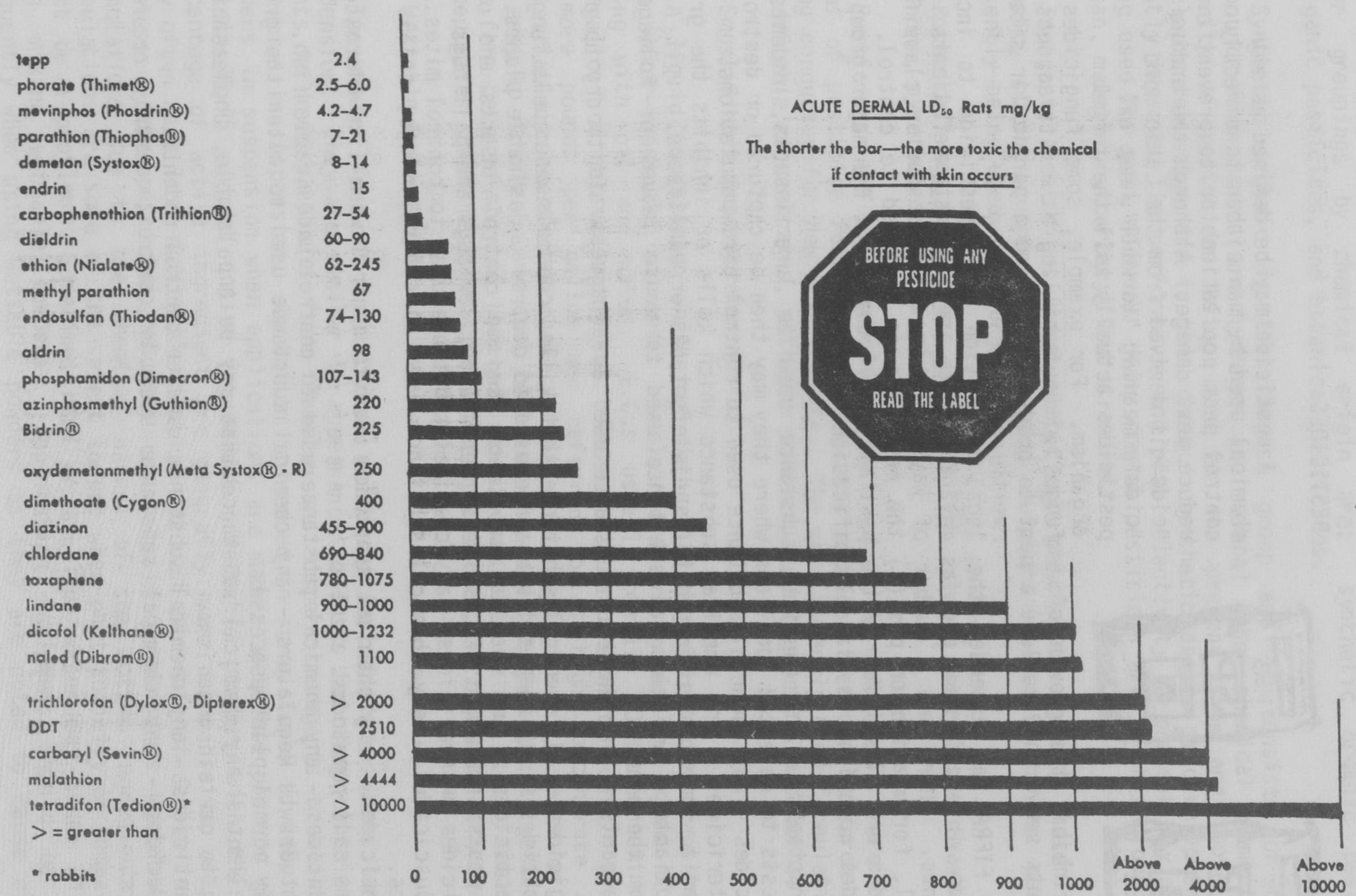
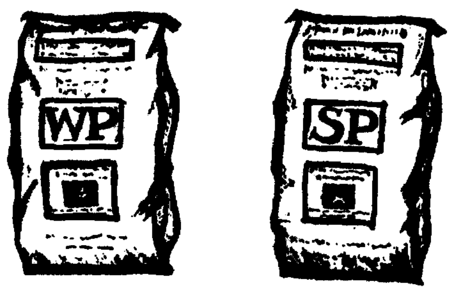

ACUTE DERMAL LD50 Rats mg/kg
The shorter the bar—the more toxic the chemical if contact with skin occurs
BEFORE USING ANY PESTICIDE
STOP
READ THE LABEL
tepp 2.4
phorate (Thimet®) 2.5–6.0
mevinphos (Phosdrin®) 4.2–4.7
parathion (Thiophos®) 7–21
demeton (Systox®) 8–14
endrin 15
carbophenothion (Trithion®) 27–54
dieldrin 60–90
ethion (Nialate®) 62–245
methyl parathion 67
endosulfan (Thiodan®) 74–130
aldrin 98
phosphamidon (Dimecron®) 107–143
azinphosmethyl (Guthion®) 220
Bidrin® 225
oxydemetonmethyl (Meta Systox® - R) 250
dimethoate (Cygon®) 400
diazinon 455–900
chlordane 690–840
toxaphene 780–1075
lindane 900–1000
dicofol (Kelthane®) 1000–1232
naled (Dibrom®) 1100
trichlorofon (Dylox®, Dipterex®) > 2000
DDT 2510
carbaryl (Sevin®) > 4000
malathion > 4444
tetradifon (Tedion®)* > 10000
> = greater than
* rabbits
0 100 200 300 400 500 600 700 800 900 1000
Above 2000
Above 4000
Above 10000

EXHIBIT 4

CHAPTER 4

PESTICIDES



A pesticide may be defined as any chemical used by man either to directly control pest populations or to prevent or reduce pest damage. Although the ending "cide" is derived from the Latin word "cida", meaning "to kill", not all pesticides actually kill the target organism. For example, some fungicides may simply inhibit the growth of a fungus without killing it. Attractants and repellants serve only to lure a pest to or divert it from a particular site.

The FIFRA has extended the legal definition of a pesticide to include compounds intended for use as plant growth regulators, defoliants, and desiccants. There are a number of ways which pesticides can be classified: chemical, formulation or pest(s) the pesticide is designed to control. Most pesticides are classified by the pest they will control. The major groups of pesticides according to this classification are:

Attractants - any chemical substance used to lure insects, rodents or other pests to selected locations where they may then be captured or destroyed.

Avicides - any chemcial substance used to control bird populations.

Bactericides - any chemical substance which kills or inhibits the growth of bacteria: sometimes referred to as disinfectants or sanitizers.

Defoliants - any chemical substance used to cause leaves or foliage to drop from the plant.

Dessicants - any chemical substance used as a harvest aid to dry up plant foliage.

Fungicides - any chemical substance that kills, controls or repels fungi.

Herbicides - any chemical substance used to control undesirable plants.

Insecticides - any chemical substance used to control insects and other related pests such as: ticks, spiders, centipedes, sow bugs and pill bugs.

Miticides or Acaricides - any chemical substance used to control mites.

Molluscicides - any chemical substance used to control slugs, snails and barnacles.

Nematicides - any chemical substance used to control worm-like microscopic organisms call nematodes.

Piscicides - any chemical substance used to control undesirable fish.

Plant Growth Regulators - any chemical substance used to alter the growth or modify normal plant processes.

Repellant - any chemical substance that may be unpalatable, unpleasant or annoying to certain organisms.

Rodenticides - any chemical substance used to control rodents.

Predacides - any chemical substance used to control, destroy or repel predators.

Pesticides can also be classified by their chemical origin. The three major groupings by chemical origin are: synthetic organic pesticides, inorganic pesticides, and botanical pesticides.

Synthetic organic is the largest group and it consists of man-made compounds from carbon and hydrogen and several other chemical elements. The majority of pesticides being used at the present time and those in the developmental stage are in this group. Synthetic pesticide developments have greatly improved the performance and pest selectivity of present day chemicals being used for pest control. Many common pesticides are in this group: 2,4-D, captan, malathion, carbaryl and atrazine.

Inorganic pesticides were the first pesticides used. These included arsenic, boron, copper, mercury and sulphur. Several of the pesticides presently being used are inorganic in nature.

Botanical pesticides are derived from plant materials. Examples are rotenone, pyrethrins and strychnine.

Pesticides are also commonly classified by formulation. There are many types of pesticide formulations available and considerable research work is being conducted for new developments. The most commonly used formulations are emulsifiable concentrates, wettable powders, dusts, granules and aerosols.

Emuslifiable Concentrates (E.C.)

A liquid formulation which has the active ingredient dissolved in one or more water-insoluble solvents. Emulsifiers are generally added to ensure mixing with oil and water. E.C.s usually contain 10-80 percent (1 - 8 lb./gallon) of active ingredient. Those formulations which contain over eight or more pounds per gallon are referred to as high concentrate liquids. Emulsifiable concentrates readily remain in suspension with water or oil and are easy to handle. Care must be taken when using high toxicity pesticides in this form because many of them are readily absorbed by the skin. Emulsifiable concentrates sometimes pose chemical compatibility and phytotoxicity problems.

Wettable Powders (WP)

The powder form of a pesticide which can be added to water to form a suspension. They are similar in appearance to dusts but they contain wetting agents to keep particles from floating and dispersion agents to maintain the particles in suspension. Agitation is needed in spray tanks to keep wettable powders in suspension when applications are made. Wettable powders generally contain 15-75 percent active ingredient. Wettable powders with the highest percentage of active ingredient are generally more desirable to use because they often have less noticeable residue and cost per unit of active ingredient is less. Some pesticide products can only be prepared as wettable powder formulations due to the chemical nature of the active ingredient. These formulations are some of the safest to use when phytotoxicity or compatibility might be a problem. Sometimes hard or alkaline water may cause difficulty when mixing wettable powders. Application equipment should be checked frequently when using wettable powders as they are noted to cause excessive wear to pumps and nozzle tips.

Flowables (F)

Flowable powder formulations are often manufactured when the active ingredients can only be produced in the form of solids or semi solids. These pesticides are sometimes formulated as flowable powders in which the active ingredient is finely ground and suspended in a liquid along with special suspending chemicals and additives. The advantage of these over conventional wettable powders is the ease in which they can be mixed into water to form a suspension.

Soluble Powders (S.P.)

Soluble powder formulations are like wettable powders in appearance. Soluble powders, however, unlike wettable powders will dissolve and form true solutions when added to water. Once forming a true solution or becoming completely dissolved, soluble powders do not require agitation in the spray tank. There are very few pesticides available as soluble powders and existing formulations contain 50 percent or more active ingredient.

Dusts (D)

Mixtures of one or more pesticides in finely ground diluent such as talc, clay or volcanic ash. Dusts are prepared to be used as dry applications and should never be mixed with water. Dusts are easier to handle from the standpoint of preparation than either emulsifiable concentrates or wettable powders. They are generally ready to use as purchased and will generally contain 1-10 percent active ingredient. The potential danger of drift from the target area is greater with dusts than with other formulations.

Granules (G)

Dry formulations with the pesticide ingredient being impregnated upon a carrier the size of sand grains or larger. Carriers are often inert materials such as clay, ground up corn cobs or walnut shells. This formulation has the least potential for drift during application and from this standpoint has considerable advantage over other types of formulations. Granules are generally available containing 1-40 percent active ingredient. Granules are easy to handle and are very desirable for homeowners to use as long as spreaders are first calibrated for the material being used. They are generally more expensive per unit of active ingredient, however, the low cost for application and variety of uses are responsible for their increase in popularity.

Aerosols (A)

Pesticides particles are in a can under pressure. When used, liquid particles are dispensed as a foam, mist or fog. One or more pesticides are used in the same formulation. As the valve is released, the contents are ejected by a propellant. The percentage of active ingredient is generally very low in aerosols and they are used quite extensively by homeowners. They are convenient and easy to use. However, the unit cost of the active ingredient is very expensive.

Fumigants

These are formulations of gas, liquid or solid which will produce a gas, vapor, fume or smoke. Their use is primarily for control of pests in closed structures, greenhouses and soil. They contain a pesticide or mixture of pesticides, a diluent and generally a substance having a characteristric odor to serve as a warning to the applicator or other persons in the area of use. They are one of the most hazardous formulations to use and extreme caution should be taken when they are used. Because of their hazardous nature, they are not generally recommended for home use.

Miscellaneous Formulations

There are several other formulations of pesticides available but less commonly used. These include:

Water soluble concentrates,
Oil soluble concentrates,
Oils,
ULV,
Invert emulsions,
Prepared baits, and
Bait concentrates.

Water soluble concentrates are completely soluble in water and form true solutions, not suspensions, when added to water.

Oil soluble concentrates are similar in appearance to emulsifiable concentrates except they will not mix with water. They are generally diluted with fuel oil, diesel oil or kerosene.

Oils used in some phases of pest control are low cost, spread easily over a surface, have excellent absorption and are relatively easy to mix and handle.

ULV (ultra low volume) are forms of concentrate materials and are formulated to be used directly without further dilution.

Invert emulsions are water in oil mixtures in which each water doplet is surrounded by oil. Some difficulty has been encountered in applying invert emulsions due to high viscosity. Their apparent advantage is to reduce drift potential in low volume and aerial applications.

Prepared baits have been used for insect and rodent control quite extensively. They are ready to use and provide adequate pest control when strategically placed.

Bait concentrates may be liquids or solids which are diluted with food or liquids before use.

In most cases, it is economical to purchase pesticides with the highest percentage of active ingredient and dilute to the desired concentration. On a unit of active ingredient basis, there is less filler or carrier, and shipping costs are lower on higher percentage concentrated pesticides. In some instances, pesticides may be available in several different formulations.

Pesticides can also be classified according to how they work. Each pesticide label will tell you how the pesticide works. The major groups of pesticides based on how they work are:

Protectants - applied to plants, animals, structures and products to prevent entry or damage by a pest,
Sterilants - make pests unable to reproduce,
Contacts - kill pests simply by coming into contact with them,
Stomach poisons - kill when swallowed,
Systemics - taken into the blood of an animal or sap of a plant. They kill the pest without harming the host.
Translocated Herbicides - kill plants by being absorbed by leaves, stems or roots and moving throughout the plant,
Anticoagulants - prevent normal clotting of the blood,
Selective - more toxic to some kinds of plants or animals than to others,
Non-selective - toxic to most plants or animals,
Pheromones - affect pests by changing their behavior.

Restricted Use/General Use?

Another way in which pesticides are classified is by restricted use or general use. This type of classification is required by the amended FIFRA. The FIFRA provides that a pesticide use shall be classified as restricted if the Administrator of EPA determines that the use of the pesticide, when applied in accordance with its directions for use, warnings and cautions, or in accordance with wide-spread and commonly recognized practices, may generally cause, without additional regulatory restrictions, unreasonable adverse effects on the environment, including injury to the applicator.

Prior to the enactment of the amended FIFRA, if a pesticide posed a threat to man or the environment, the only legal action available to EPA was to cancel the use of the particular pesticide. This type of action denies the use of the pesticide to everyone. By classifying pesticides for restricted use, EPA can now allow the use of some pesticides to continue while restricting their use to only qualified (certified) applicators. The classification of pesticides and the certification of applicators has permitted EPA to allow the continued use of a number of pesticides which might have otherwise been subject to cancellation.

When considering whether or not to classify a pesticide for restricted use, EPA takes into account a number of items. These include: 1) the accident history associated with the pesticide, 2) the pesticide's acute (immediate) toxicity or chronic (long-term) toxicity, and 3) the pesticide's hazards or potential hazard to non-target species.

Accident History - When reviewing a pesticide's accident history, EPA reviews all available data on the pesticide's past use. This includes research data provided by the pesticide manufacturer, independent research groups, and the USDA Extension Service. EPA also examines enforcement actions it has taken or actions taken by individual state pesticide enforcement agencies as well as information provided by poison control centers. This data helps EPA make a sound determination on whether or not a pesticide should be classified for restricted use based upon it's past use history.

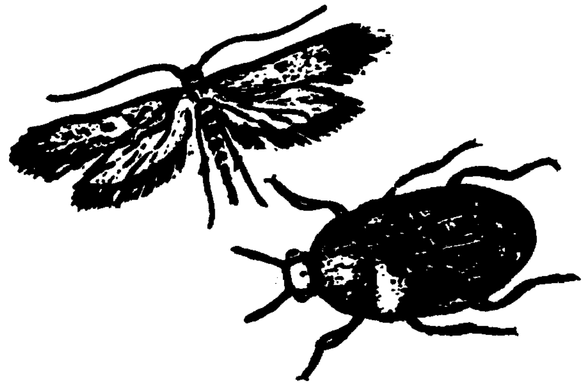
Toxicity - The toxicity of each pesticide which is being considered for classification as restricted use is reviewed. Pesticides which are highly toxic to man or other organisms which might come into contact with it may be classified for restricted use based upon this toxicity. The concentration of the pesticide is also taken into consideration. The higher the concentration of a pesticide, the more likely it may be classified for restricted use.

Hazard to Non-target Species - A number of pesticides do not readily pose a hazard to the applicator. However, the pesticides may have characteristics which may be hazardous to non-target species. An example is pesticides which are very persistent in the environment or pose secondary poisoning hazards.

After EPA has reviewed all of the information on a particular pesticide and makes a determination that all or some of its uses should be classified for restricted use, it will publish a notice in the Federal Register announcing its decision and ask for public comment. Based upon the input EPA receives, the Agency will make a final determination on the classification of the pesticide being considered. This classification can range from all uses being classified as restricted to none of the uses being classified as restricted. After a final determination that a pesticide will be classified as restricted use, EPA will notify the pesticide manufacturer. The manufacturer will be given a certain number of days in which to change the product labeling.

CHAPTER 5

PESTS



Man's success in a hostile environment is determined by his ability to adapt or to change his surroundings to his benefit. An area in which man does not exist has no pests. "Pest" is a man-made concept and is generally considered to include those organisms which come into conflict with him for his crops and livestock, affect his health or comfort or destroy his property.

Man prefers certain plants and animals that provide him food and fiber. But man also provides good growing conditions for other plants and animals that harm him or his crops. These living things that compete with man for food and fiber or attack him directly are pests. The living plant or animal a pest depends on for survival is called the host.

The first step in solving any problem is to understand what is causing it. So the first step in pest control is to recognize the pests you need to control.

Pests can be put into five main groups:

Insects (plus mites, ticks, and spiders),
Snails and slugs,
Vertebrates,
Weeds, and
Plant disease agents.

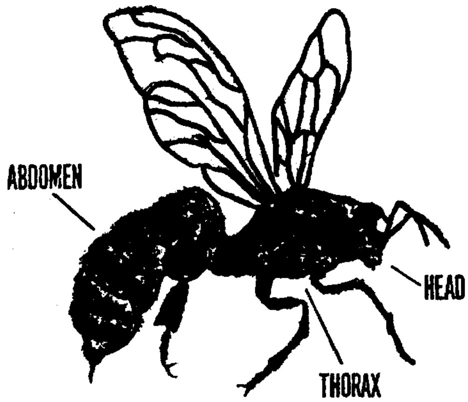
INSECTS

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

Many types of insects affect many types of crops. They cause damage in a variety of ways. They may feed on leaves, tunnel or bore in stems, stalks, and branches, feed on and tunnel in roots, feed on and in seeds and nuts, suck the sap from leaves, stems, roots, fruits and flowers and carry plant disease agents.

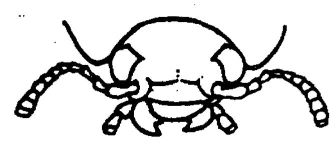
The plants can be damaged, weakened or killed. This causes reduced yields, lowered quality and ugly plant or plant products that cannot be sold. Even after harvest, insects continue their damage in the stored or processed products. Insects also feed on and in man and other animals. Some of these pests carry disease agents which have caused millions of deaths to man and livestock. However, not all insects are pests. Some help man by doing such things as pollinating plants or feeding on other insects that are pests.

Recognizing Common Features of Insects



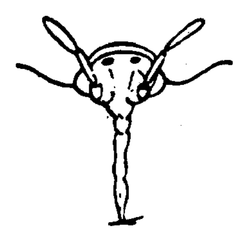
All adult insects have two things in common - they have six legs and three body parts (head, thorax and abdomen). But how do you tell one insect from another? The most important parts to look at are wings and mouthparts. Some insects have no wings. Other insects may have two or four wings. When wings are present, they are found on the thorax of the insect. The insect's legs are also found in the thorax. The wings vary in shape, size, thickness and structure.

As mentioned previously, the mouthparts are very important when trying to identify an insect as well as when selecting the proper pesticide to control the pest. There are two major types of mouthparts - chewing and sucking.



Chewing mouthparts are generally composed of a labrum (upper lip), a pair of cutting or crushing mandibles, a pair of maxillae, a labium (lower lip) and a tongue-like hypopharynx. The mandibles and maxillae, or jaws work sideways and are used to cut off and chew or grind solid food. A typical example is the type of mouthparts found in a grasshopper or cricket. In some forms of insects, mainly predators, the mandibles are long and sickle shaped. In others, such as honey bees, the hypopharynx or tongue, is greatly modified.

Insects with chewing mouthparts include adult grasshoppers and crickets, dragon flies, damsel flies, lace wing flies, beetles, bees, ants and wasps.

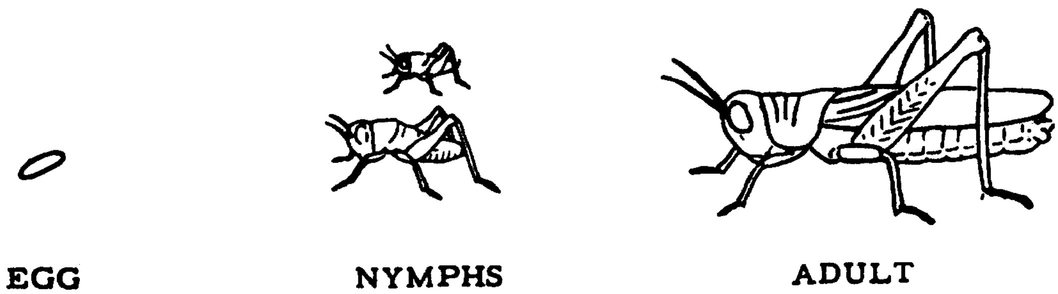


Sucking mouthparts are those in which the parts described above are highly modified into some form of organ for securing liquid food. They may be piercing-sucking as in the mosquitoes, true bugs, aphids and stable flies; lapping or sponging as in the house fly; rasping-sucking as in the thrips or tube like as in the moths and butterflies.

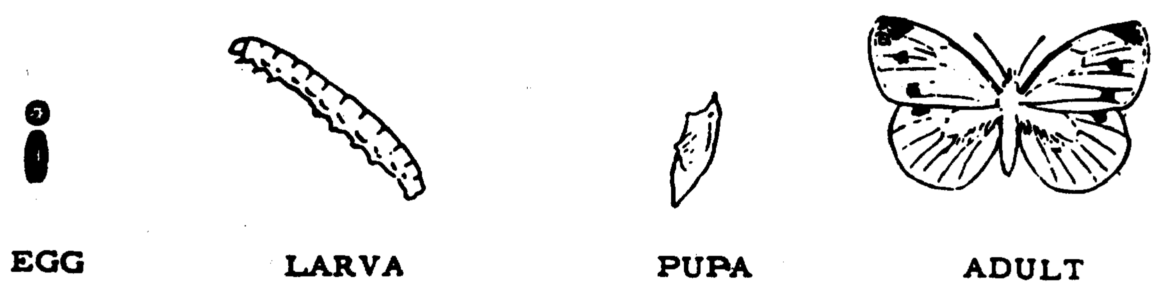
Most insects change from the time they hatch from eggs until they are full grown. This change in form is called metamorphosis. It may be a rather gradual change involving little more than an increase in size to a very dramatic difference between the young and the adult.

There are several ways of characterizing the types of metamorphosis but the generally used method is to divide them into simple or incomplete and complete.

In the simple type of metamorphosis the insects which hatch from the eggs are called nymphs. As they feed and grow, they shed their skins or molt. In the winged species wings first appear as pad-like buds on the nymphs. Each stage between molts is referred to as an instar. There is no prolonged resting period before the adult stage is reached. Insects which have simple or incomplete metamorphosis are: dragon flies, grasshoppers, crickets, termites, chewing lice, sucking lice, thrips, aphids and leafhoppers.



The complete metamorphosis involves a very major change in form between the young and the adult. In the winged forms the wings develop internally instead of externally. The typical development involves the egg, larva, pupa and adult. The larvae may go through a number of instars and molts as they grow. The pupae may take several forms. They may be exposed or contained in a capsule like a silken cocoon. Some types of insects which undergo complete metamorphosis are: lace wings, beetles, moths, butterflies, mosquitoes, fleas, bees, ants, and wasps.



Common Agricultural Insect Pests

CORN

Corn Rootworms

The Western corn rootworm is one of the most predominant soil insects attacking corn. It is only a problem in ground that is planted to corn for more than one year. This insect overwinters as eggs that are deposited by the adult female beetle in late summer and fall. The eggs hatch the first part of June and the young worms begin to feed on the roots of the new plant. The rootworms are very small, only about one-half inch long when fully grown, a dirty white color with dark heads and a slender body. When the worms mature, they pupate in the soil. Adult beetles come out the latter part of the summer to feed on pollen and silks, mate and lay eggs. Destruction of the silk can cause ears to develop poorly. Adult beetles are greenish-yellow in color, about one-half inch long and marked with black stripes or marks on the wing cover.

European Corn Borer

The European corn borer overwinters as a mature larvae in a tunnel within the stalk, stubble or corn cob. In May the larvae pupates inside it's tunnel and forms a brown, cigar-shaped pupa. The adult form or moth comes out in June. The actual time of moth emergence, mating and laying of eggs will depend upon spring conditions. Cooler weather will slow down emergence and warmer weather will speed it up. The female moth is small with a wingspread of about 1 inch and is pale yellow to light brown in color. The outer third of the wings is usually crossed by two dark zig zag lines. Male moths are smaller and darker in color. Moths are attracted to the tallest and most vigorous corn growing in the area. Eggs are generally laid near the mid-ribs. Eggs hatch in a circular pattern. Eventually the larvae will bore into the stalks.

When first brood infestations are heavy, yields may be seriously affected. Larvae will complete their development, pupate and a second moth flight will occur. The second brood moth flight is somewhat erradic and can extend from July to September. Eggs from the second generation usually are laid around the ear. The second brood larvae are destructive in that they are responsible for a lot of stalk breakage below the ear and a lot of ear droppage because of feeding on shanks.

ALFALFA

Alfalfa Weevil

This insect is one of the most serious insect pests of alfalfa in many areas of the West. During years of peak populations, worms or larvae counts may reach to a hundred per sweep of an insect net. Such populations will reduce the alfalfa to just stems. Damaged hay will lose most of its carotene and protein content. Primary damage is to first cutting although larvae may attack new growth on second cutting if not controlled. Alfalfa weevils like to feed on the upper parts of the plant and between leaf veins. A damaged field can be recognized from a distance by its characteristic grayish cast.

The adult weevil (snout beetle) overwinters in the soil or crown of the plants. It makes its appearance in early spring as soon as or before the weather is warm enough to start the hay. Some eggs may be deposited in crevices in the old stubble. However, the preferable location is inside the stems of the new growth. The female beetles chew a small hole in the stem and then inserts the eggs inside. From 2 to 25 eggs are laid in each stem. The female is capable of laying 600-800 eggs during about a 30 day period.

The eggs at first are yellow and are easily visible if an infested stem is broken open. Upon hatching, the larvae make their way to the new growth. Characteristically, they curl over the edge of the leaf while feeding. At first they are very tiny (1/16 of an inch). When full grown they measure about 1/3 of an inch, are light green in color with a median white stripe on the back and on each side. The larval period is about three weeks. If the hay is cut before the larvae stop feeding, they will drop to the ground and some will reach the crown where they feed on the new shoots. This often retards the second cutting a week or so.

The alfalfa weevil pupates in a flimsy silken cocoon in the crown of the alfalfa. The cocoon may be partially concealed by folded leaves. There is only one generation a year. The adults that emerge from the cocoons in mid summer hibernate through the winter.

Pea Aphids

The pea aphids development is favored by cool dry weather and when this occurs, they can cause considerable damage. In outbreak years, early infestations usually appear in the lower elevations in the river valleys and as the season progresses the aphids move to the higher elevations. The aphids suck out the plant juices. Infested alfalfa is often stunted, misshaped and has a pale or yellowish cast. Seedling plants are often killed. Heaviest aphid populations occur in the spring and early summer but they may persist throughout the growing season.

Usually when pea aphids are abundant, a number of predators such as the lady beetle and lacewings will develop. Generally, the predators do not appear in sufficient numbers until much of the aphid damage has been done. Later predators and parasites may catch up and bring the aphids under control.

The pea aphid is one of the larger aphid species, 1/6 inch long and pea-green in color. Both winged and wingless forms may be present. A complete cycle may require only 2 weeks. Consequently, several generations are produced each year.

BEANS

Mexican Bean Beetle

The mexican bean beetle is usually present to some extent each year and control is usually necessary. Both the adult beetles and larvae feed on plants. The leaves are skeletonized and often the pods are attacked.

The adult beetle is copper colored with black spots on the wing covers. It comes out of hibernation in late May, it feeds for a short period and then lays its eggs in clusters on the underneath surface of the leaves. In a few days the eggs hatch, producing yellow larvae which consume much of the leaf tissue. The larvae are about 1/3 inch long when fully grown. They pupate on the leaves. The beetle can complete its life cycle in about a month. There may be 2 or 3 generations during the growing season.

SMALL GRAINS

Army Cutworms

This cutworm is a subterranean species commonly found damaging winter wheat early in the spring. The mature cutworm is dull green to brown in color with a faint pale yellow stripe down the back and some brown freckles on the head capsule.

The army cutworm has one generation per year. The eggs hatch in 1 to 2 weeks and the young larvae feed until cold weather. They pass the winter as partly grown larvae. They probably feed occasionally in the warm weather during the winter months. As soon as the weather warms up, the larvae resume feeding and it is during this time (March and April) that they do the greatest damage. The larvae become full grown in April and enter the ground for pupation. Adults begin to appear in May and in years of abundance are often a nuisance in dwellings and about lights durings most of June.

Adults have been seen at high altitudes in the Rocky Mountains during the summer months. The moths reappear in September in greatly reduced numbers and begin depositing their eggs. The pupa appears to be the overwintering stage. A relatively few survivors are able to carry the species to big population levels. This is due to their enormous reproductive capacities.

POTATOES

Colorado Potato Beetle

The Colorado potato beetle is one of the most commonly known insects in the United States. Both the adult beetle and larvae feed on potatoes devouring the foliage and terminal growth. Sometimes the injury is severe enough to kill the plant.

The beetle is yellow with 10 black stripes extending lengthwise on the wings. It is about 3/8 of an inch long and 1/4 of an inch wide. The beetles come out of winter hibernation in the spring, mate and lay orange colored eggs in clusters on the underside of the leaves. These eggs hatch in about a week and produce humped reddish larvae which have 2 rows of black spots along the sides of their bodies. They feed and become full grown in 2 or 3 weeks at which time they are about 1/2 inch long. They then pupate in the soil. There may be 2 generations a year under certain conditions.

Leafhoppers

While there may be more than one specie of leafhoppers on potatoes, the aster leafhopper is the most serious since it transmits the aster yellow virus to potatoes as well as many other culivated plants. This leafhopper is about 1/8 inch long, light green in color and is characterized by 6 tiny black spots on the top of its head. It is a migratory species and usually begins to increase in number in late June or July. Potatoes affected with aster yellow are usually stunted, may show slender purple shoots and very often form aerial tubers in the axils of the leaves. It overwinters in the adult stage in the milder climates and when it becomes active in the spring, eggs are deposited under the epidermus of the leaves. Within 2 weeks these eggs hatch producing light green nymphs which may be found feeding on the foliage. Both the nymphs and adults are capable of transmitting the virus after the disease has incubated in their bodies for at least 10 days. The nymphal period lasts from 2 to 4 weeks. There may be more than one generation per year.

SUGAR BEETS

Webworms

These worms are the most destructive leaf-feeding insects attacking sugar beets. Both the alfalfa webworm and the beet webworm may be found on beets. Their life history and habits are quite similar. Mature worms are about 1 inch long, green to nearly black in color, with light stripes on the back and spots on the side of each segment. Heavy attacks while beet plants are small may kill out entire stands. Attacks when beet plants are larger can cause severe defoliations and losses in production.

As indicated in their name, these worms spin a small amount of webbing as they feed on the plant. Many times the feeding begins in the central leaves. When attacks are severe, more than 1 to 3 worms per plant will be found. In large scale outbreaks, the worms move in large masses from field to field.

There can be 2 to 3 generations of worms per year. Signs of infestation include webbing around the control of leaves at the base of the plants, defoliation of the leaves or the presence of small, pearly white egg masses on the leaves. Eggs are quite small, about the size of a pin head.

Beet Leafhoppers

This leafhopper is commonly found on beets in certain areas of the country. Its potential for carrying a virus disease known as curly top makes it a serious pest.

The beet leafhopper is a small, wedge-shaped insect, approximately 1/4 inch long when full grown and varies in color from light yellowish green to a grayish brown. When they fly they appear white and have often been given the name "white fly".

Beet leafhoppers breed in dry, desert areas of the West and southwest feeding on many native plants. In spring, when rangeland weed hosts mature, beet leafhoppers migrate with prevailing winds to other areas and will attack growing beets. Only a small portion of the leafhoppers carry the virus. The incidence of disease is dependent upon how soon leafhoppers have moved into a field and how many of the leafhoppers are carrying the disease.

The eggs of the beet leafhopper are laid in the leaves of the beet plant on which the adult feeds. Eggs hatch in a few days into tiny nymphs. The nymphs feed and grow on the plants, eventually becoming adults in 3 to 8 weeks.

FRUITS

Codling Moth

The insect known as the codling moth has caused greater losses to apple and pear growers than any other pest. It is found wherever apples and pears are grown, producing the familiar "apple worm" found in the fruit.

The codling moth spends the winter inside a silken cocoon on the tree or almost anywhere in the orchard or packing shed area. The larvae are found hibernating on wood, sacks, or corrugated paper and often in packing boxes, posts, and trees. When warm spring days begin, the larvae transform into pupae within the silken cocoon. By blossom time pupation is generally complete. Typically, moth emergence occurs just at petal fall. The first moths to emerge are males. The numbers of females progressively increases in the next few days. If the weather is cool, adult emergence is prolonged and may extend over a month. In warm spring weather peak emergence of the moths will occur in less than a week. Cool weather retards egg deposition and has the effect of spreading each generation through the season.

The codling moth egg is a white translucent circular disk appressed to the leaf. It resembles the head of a pin that has been pushed through the leaf. When numerous, the eggs are easily visible. Normally the egg hatches in 8 to 14 days. In the spring, all egg deposition is on the leaves but subsequent summer generation egg deposition is largely on the fruit. The larvae may feed on foliage when first hatched but they soon migrate to nearby apples and begin to make entry. At this time the calyx end of the apple is a cup-like opening which is a particularly favorable site for entry. Occasionally the stem end of the apple will be entered. Generally the larvae reach maturity after about 3 weeks inside the apple. Then they emerge, either to migrate back to the twigs or trunk or to drop to the ground and pupate. Twelve to 14 days are required for the pupal stage at this time of the year and the second brood of moths appear about the first of July. Forty-eight to 50 days are required to complete a generation of the codling moth. The third brood generally appears in mid-August. Third brood moths generally do not cause much damage but their activity may interfere with pear and apple harvests.

When the first summer generation has been completed, only about 2/3 of the moths emerge. About 1/3 enter the overwintering condition and emerge the following year. Over half of the second summer generation enters the overwintering condition and most or all of the third does so.

The codling moth is a small grey moth about 1/2 inch long with a chocolate or bronze colored rounded spot at the apex of the wings. The grey appearance of the rest of the body takes the form of undulating minute grey lines with interspersed brown.

Two-Spotted Mite

The two-spotted mite overwinters primarily as an adult female in soil and trash near the base of fruit trees. In general it is thought that any mites on the trunk migrate down to emerging cover crop vegetation early in the season. At this time mite populations exhibit a preference for herbaceous plants and seem to attack fruit secondarily later in the summer. Since the two-spotted mite spends half the growing season on the cover crop, considerable control can be achieved through cultural practices such as fall tilling, or destroying or spraying the weeds around the bases of the trees.

The life cycle of the two-spotted mite, beginning with the egg hatch, passes through three nymphal stages to the adult stage. The egg is spherical and clear when deposited and is commonly found on the undersides of leaves. Typically all stages are present at the same time. The immature larave is six-legged and nearly colorless, gradually becoming pale green. The larave molts into a protonymph which is somewhat larger, is pale green in color that gradually darkens and has 4 pairs of legs. After another molt, the deutonymph molts and becomes a mature adult.

At average temperatures, about 4 days are required to hatch the egg. In the cool part of the season, 2 weeks or more may be required. The length of the larval stage also varies with temperature and may range from 1 to 10 days. The length of the life cycle of mites varies from about 5 to 30 days.

Each adult female lays from 40 to 100 eggs. The adult life span may be up to 2 months but averages 15 to 30 days. Unfertilized females produce young, all of which are males. Under average growing conditions, probably 10 generations of mites are produced in a season. As temperatures become cooler in the fall and the days shorter, the females turn orange and congregate in crotches and under bark scales of the trunk and scaffold limbs. Clusters of orange mites are often found in the calyx and/or stem end of apples at this time of year. There is considerable mortality to the overwintering mites.

The injury caused by mite populations is largely confined to foliage feeding. This feeding causes collapse of plant cells and loss of vigor in the tree. When infestations are heavy, the mite populations retard fruit color development to such an extent that fruit quality may be downgraded. High mite populations can also affect fruit bud formation.

CATTLE

House and Stable Flies

Stable flies and house flies look very much alike and have similar habits. These two flies are primarily pests of animals around feedlots, yards and pens. The stable fly looks much like the house fly except it has piercing-sucking mouthparts and are vicious biters and blood suckers. House flies do not feed upon the animals but they are extremely annoying. Both flies breed in decaying organic materials. If animals use lots to water, flies attack them and may return to the pastures with the cattle. Stable flies rest on shady surfaces around barns, bunks, tanks or vegetation in the vicinity of animal yards. House flies rest on sunny surfaces during the day, roosting at night inside of barns and sheds (usually on ceilings).

Residual application to resting sites helps to control adults of both flies. Stable and house flies have similar life cycles. Eggs are laid in decaying organic matter and hatch in 1 to 3 days producing white maggots. The maggots feed on the decaying organic matter such as manure and can complete their growth in 6 to 7 days then turn into pupa. The pupal stage varies from 5 to 10 days on the average before adult flies emerge.

Since both flies develop in manure, sanitation is a very essential part of control. Elimination of natural breeding sites such as manure and water soaked feeds and straw around premises is important. Stacking of manure will help control flies in areas where it is not practical to remove the manure immediately.

Treatment of animals, either with sprays or by dust bags and self treating rubbers is not too effective for control of stable flies because these pests feed primarily on the front legs of the animal. Treatment of animals for house flies is quite temporary and it should be remembered that they do not require feeding on the animals as do stable flies.

Baits containing approved insecticides are quite effective in controlling numbers of adult house flies. Baits should be placed so that animals, children and pets do not have access to them.

Cattle Scabies

Scabies is a microscopic mite that burrows in the skin where they produce definite burrows in which the females deposit their eggs. These parasites pierce the skin and suck lymph and epidermal cells. Their activities produce a marked irritation which causes intense itching and scratching. The resulting inflammation of the skin is accompanied by exudate which coagulates and forms a yellowish crust on the skin surface. This skin area then becomes thickened and wrinkled with a consequent loss of hair.

Spread of scabies among animals is rapid and is mainly by transfer of the larvae nymphs and fertilized females from one animal to another. Scabies falls under a Federal quarantine and infected and exposed animals must be treated under the supervision of a Federal veterinarian. If the symptoms described above are seen on cattle, the veterinarian in the area should be notified so that diagnosis can be made and the infestation thus stopped as soon as possible.

The insect pests described above are only a few of the the major pests which can affect your farming or ranching operation. If you find an insect which you cannot identify, contact your local county extension agent or agricultural consultant. The various extension services have written information on insect identification and treatment recommendations are available. Remember to identify the pest properly before you use any pesticide. Then only use a pesticide which is registered for that particular use and follow the label directions for safe and proper use.

Principles and Methods of Insect Control

Plant Insect Control

Present day insect problems, created or aggravated by the concentration of host plants (large areas with the same crop such as wheat or corn) are diverse and without simple solutions. Farmers and ranchers should follow the instructions and advice of competent fieldmen or consultants in order to effectively cope with the wide variety of pests found in modern agriculture.

Whether the farmer or a field consultant is responsible for conducting a sound pest control program, a knowledge of insect identification, growth patterns and development, and life cycles is necessary. Life cycle information is essential in the timing of control measures. Only through a thorough knowledge of a pest's life cycle can one hope to aim control measures effectively at its most vulnerable stage of growth.

Crop value is an important consideration. Control of pest insects is usually justifiable when the increase in marketable yield produced is worth more than the cost of control. If the cost of controlling the pest is more than the loss due to the pest, control measures may not be beneficial.

Preventative control measures can be used when you know through experience that a certain pest or pests will develop to a damaging point in a given area year after year. Some early treatments tend to control a pest before it has reached its maximum rate of development and reproduction and before the crop foliage has grown to the point where it is difficult to reach the pest with sprays, granules or dusts. However, one should generally wait to treat with a pesticide until the pest population is causing more damage than the cost of treatment.

Outbreaks or epidemics of insect pests are usually caused by one or more of the following:

a. large scale production of a single crop,
b. introduction of a pest into a favorable new area without its natural enemies,
c. weather conditions are favorable for rapid development and reproduction of a pest. These conditions may also be unfavorable to the pest's natural enemies,
d. use of insecticides which may kill the pest's natural enemies and create conditions which may be favorable for the pest to multiply unmolested or only partially controlled,
e. use of poor cultural practices which encourage pest infestations,
f. destruction of natural plant, animal and micro-organism communities which otherwise provide normal control of insect population levels.

There are a number of types of insect control procedures available. These include: biological, mechanical, cultural, chemical, reproductive and legal.

Biological Control

Biological control can be defined as the action of parasites, predators or pathogens (disease producing organisms) on an insect pest host or prey population which will reduce the level of the pest below normal population levels. Generally, biological control refers to manipulations by man as distinguished from natural enemies and natural control.

Biological control has a number of distinct advantages, three of which are permanence, safety and economy. Once biological control is established, it is relatively permanent and has no side effects such as toxicity, environmental pollution or use hazards.

There are three kinds of traditional biological controls:
a. the introduction of exotic or foreign kinds of parasites,
b. conservation of parasites and predators,
c. augmentation of parasites and predators.

The use of insect pathogens such as fungi, bacteria and viruses is another one of the techniques employed in the biological control of insects.

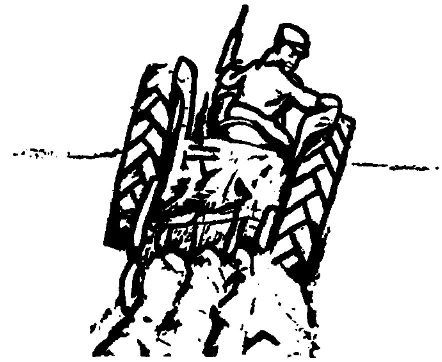
Natural enemies should be able to play a role in most crop ecosystems. One factor which may impede their effectiveness is climate. Other reasons their activity may be inhibited include environmental factors such as dust, competitors, drift of pesticides from adjoining fields or necessary pesticides used on the crop.

Biological controls are not suitable in many pest situations. It takes time for the parasites and/or predators to reproduce sufficiently to bring the pest under control. A farmer often feels that he cannot wait for the natural enemy to do the job because he needs a marketable crop each year. Other technical difficulties involve such items as determination of which parasites or predators to introduce, whether to use more than one parasitic species at a time, how to eliminate secondary parasites that prey on the beneficial form and whether a continuous program may be feasible. There is also the problem of protecting such predators and/or parasites from pesticides.

Mechanical Control

Mechanical control is the reduction of insect populations by means of devices which affect them directly or which alter their physical environment radically. These methods are often hard to distinguish from cultural methods. However, mechanical controls involve special physical measures rather than normal farm practices. They tend to require considerable time and labor and often are impactical on a large scale.

Hand picking, shingling and trapping are familiar mechanical methods of insect control. Screens, barriers, sticky bands and shading devices represent other mechanical methods of insect control.



Cultural Control

Cultural control is the reduction of insect populations by the utilization of agricultural practices. It has also been defined as "making environments unfavorable for pests." Cultural control usually involves certain changes in normal farming practices rather than the addition of special procedures.

Knowledge of the life history of a pest species is essential to the effective use of cultural control methods. The principle of the "weakest link" or most vulnerable part of the life cycle usually applies. The environment is changed by altering farming practices at the correct time so as to kill the pests or to slow down their multiplication. In this way, the method is aimed more at prevention than at a cure.

Since cultural methods are usually economical, they are especially useful against pests of low value (per unit) crops. Such methods are particularly applicable to field crops.

Several methods of cultural control practices are:

Rotation - Certain kinds of crop rotation may aid in the control of pests. Insects which are reduced effectively by rotations usually have a long life cycle and a limited host range and are relatively immobile in some stage of their development. Changing crops in a rotation system isolates such pests from their food supply. Wireworms, white grubs and corn rootworms are good examples. Your local extension service office may be able to provide you with information on other pests and crops which could be used in a rotational system.

Location - Careful choice of crops to be planted next to each other may help reduce insect damage.

Trap Crop - Small plantings of a susceptible or preferred crop may be established near a major crop to act as a "trap". After the pest insect has been attracted to the trap crop, it is usually treated with insecticides, plowed under or both.

Tillage - The use of tillage operations to reduce populations of soil inhabiting insects may work in several ways: change physical condition of soil, bury a stage of the pest, expose a stage of the pest, mechanically damage some stage of the insect, eliminate host plants of the pest and hasten growth or increase vigor of the crop.

Clean Culture - Removal of crop residues, disposal of volunteer plants, and burning of chaff stacks are measures commonly applied against vegetable and field crops.

Timing - Changes in planting time or harvesting time are used to keep the infesting stage of insects separated from the susceptible stage of the crop.

Resistant Plant Varieties - The sources of resistance to insects in crops have been classified as non-preference, antibiosis and tolerance. Insect preference for a certain host plant is related to color, light reflection, physical structure of the surface and chemical stimuli such as taste and odor.

Antibiosis is defined as an adverse effect of the plant upon the insect. This may be caused either by the deleterious effect of a specific chemical or by the lack of a specific nutrient requirment.

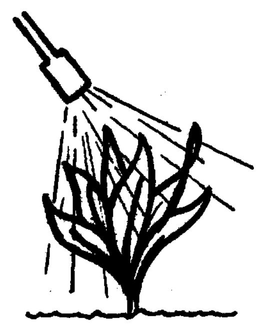
Tolerance is the term applied to the general vigor of certain plants which may be able to withstand the attack of pests such as sucking insects. Tolerances also include the ability to repair tissues and recover from an attack.

Advantages of the use of resistant varieties include a cumulative and persistent effect which often eliminates pest damage within a few seasons, lack of dangers to man and domestic animals and low cost (once the program is established).

Reproductive Control

Reproductive control is the reduction of insect populations by means of physical treatments or substances which cause sterility, alter sexual behavior or otherwise disrupt the normal reproduction of insects.

Chemical Control



Chemical control is the reduction of insect populations or prevention of insect injury by the use of chemicals to poison them, attract them to other devices or repel them from specified areas. Chemicals are highly effective and economical and can be applied quickly to have an immediate impact on a pest population. When pest populations approach economic levels and natural controls are inadequate, pesticide applications may be the only hope to save the crop so that it can be marketed. It seems clear that pesticides must and will continue to be used in a major way in integrated pest management programs.

At times pesticides are essential for:

a. the maintenance of adequate crop production,
b. the protection of forest resources,
c. the preservation of man's health and well being.

One of the advantages of the use of insecticides in many crop ecosystems is that more than one major pest may be controlled with a single application. Pesticides are especially important as short term pest management tools. The important consideration is that pesticides be used when possible in a manner that is harmonious with other elements of the agro-ecosystem and augmenting other control methods.

Insecticides do have certain well know limitations which include:

a. development in many areas of strains of pests that are resistant to pesticides,
b. only temporary control effects on insect populations often requiring repeated treatments,
c. presence of residues of the pesticide in the harvested crop,
d. outbreaks resulting from the destruction of their natural enemies,
e. undesirable side effects on non-target organisms including: parasites, predators, fish, birds, and other wildlife, honey bees and other necessary pollinators, man and his domestic animals and the crop plant,
f. direct hazards of the pesticide on the applicator and other persons in or near the area of application.

Legal Control

Legal control is the lawful regulation of areas to eradicate, prevent or control infestation or reduce damage by insects. This involves mainly the use of quarantines and pest control procedures. Federal and state officials often work with legally established local, community or county districts such as weed districts or grasshopper control programs to control pests.

Integrated Pest Management (IPM)

IPM is the management of insect populations by the utilization of all suitable techniques in a compatible manner so that damage is kept below economic levels. It is an ecological approach that not only avoids economic damage but also minimizes adverse effects to man and the environment.

Animal Insect Control

Control or management of insects is an important component of the overall management program of the progressive livestock producer. Insect control or mangement is usually accomplished through the use of (a) practices that will avoid or reduce insect problems and (b) the use of an insecticide that will greatly reduce or eradicate a pest problem. Non-chemical methods of controlling insects on animals are more limited than with insect control on plants.

Biological Control

Biological control of insects on animals follows the same basic concept as using biological control in controlling plant insects. Parasites and predators of insect pests may be used alone or in conjuction with the use of other control methods.

Mechanical Control

Mechanical control involves special physical measures such as the use of screens or barriers, use of pheromone traps or electric insect traps. Sticky bands in animal pens are often used in controlling animal insect pests. One of the major mechanical or cultural methods of controlling animal pests is proper sanitation in and around animal pens. Poorly kept livestock areas tend to be excellent breeding grounds for numerous animal pests. Good manure management is a key to controlling livestock pests.

Chemical Control

Use of insecticides is the most common type of animal pest control. Insecticides can be applied to animals safely if you observe the following guidelines:

a. use the correct product,
b. apply the right amount,
c. apply it in the proper manner,
d. observe all associated safety procedures,
e. observe the proper time interval between application and slaughter or freshing.

Safety precautions must be observed when applying pesticides to animals. Some insecticides are readily absorbed into the milk but not necessarily into the meat. Some products can therefore be used on beef animals but not on milking dairy cattle.

Some insecticides are closely related to chemicals in medications. If you or your veterinarian are treating an animal for a particular ailment and at the same time you decide to treat the animal for lice, grubs, etc.; you may be subjecting that animal to an abnormal amount of chemical. Be sure you know what chemicals each of your animals has been exposed to. Recognize the fact that some animals cannot be sprayed (i.e. horses), that others may react adversely if treated at the wrong time (i.e. cattle treated for grubs) and that some may inadvertently consume insecticides (i.e. thirsty animals may drink insecticides, chickens may eat fly bait).

It is absolutely essential that all necessary precautions be taken to ensure that an insecticide does not contaminate feed or drinking water. In addition, be certain that run-off from animals does not drain into a river, lake, pond or other water supply.

There are several methods of applying pesticides to animals and farm buildings. These include: high pressure hydraulic sprayers, mist blowers, self-treating oilers, dipping vats, dust bags and through feed and mineral mixes.

A high pressure hydraulic sprayer with a single outlet gun can be used to spray large animals confined to a holding pen. Care must be taken to ensure that all animals are thoroughly wetted. The high pressures provide the penetration into fur and wool that is necessary for the control of lice, wool maggots, etc.

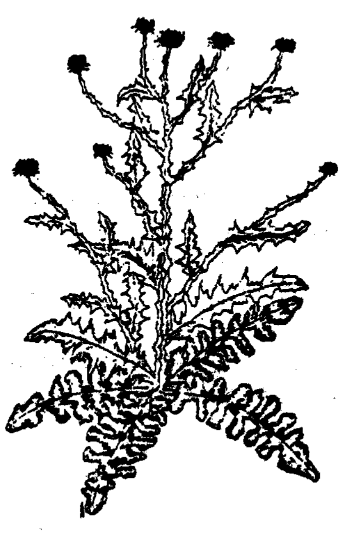
When adjusted to lower pressures, a high pressure sprayer can be used for applying residual sprays to walls and other surfaces of farm buildings and pens for fly control, etc. These sprayers usually have piston pumps and mechanical agitators and are solidly built and durable.

Hand held electrically operated mist blowers and foggers are available and are satisfactory for both space application of insecticides and for application of sprays directly to the animal. They are primarily used for louse and chorioptic mange (barn itch) control. There are also permanently installed automatic mist blowers and foggers designed to spray animals as they pass through an entrance or exit of a barn or corral. Care must be taken to ensure that they are properly adjusted and calibrated and that the correct formulation is used.

Self treating oilers and dust bags are popular ways of applying some kinds of insecticides to cattle. Selection of the right product and proper installation of the equipment are essential considerations. Pour-on and spot-on treatments are used to control cattle grubs and to suppress louse populations. It is important that you use the metering or measuring device supplied with the product.

It is essential for all applications of insecticides to livestock that you know the approximate weight of each animal to be treated. Some insecticides can be administered through feed and mineral mixes. These should not be used simultaneously. To be effective and safe, each animal must consume a precise amount based on live weight each day. Is some cases, such as in a beef feedlot, this can be easily done by knowing the amount of feed consumed daily then blending in the required amount of insecticide assuming each animal will eat the same quantity of feed. Difficulties arise when a farm has animals of many different weights and in dairy operations where animals are fed different amounts based on milk production. The farmer should ideally have different blends for several groups of animals.

PLANTS



Unlike other agricultural pests, weeds don't attack our crops or livestock directly. For that very reason, losses due to weeds are less noticeable and often more significant than losses due to other pests.

The most common agricultural weeds are species adapted to invade and survive on cultivated land. They grow where the natural vegetation has been disturbed. In a sense, they are dependent on our use and manipulation of the land. Most have had a long association with man and many of our most troublesome weeds were introduced into this country by early settlers. They have had ample time to become quite adept at living in man-made environments. Common weeds such as lambsquarter, pigweed, sheperd's purse, bindweed and a host of others are "species of cultivation" that are found worldwide in nearly all agricultural areas.

What is a weed? There is no single commonly accepted definition of a weed. There is no listing that places desirable plants in one column and weeds or undesirable plants in another. Although some species are normally thought of as weeds, their designation as such ultimately depends upon where they are growing. As an example, quackgrass is considered a weed in many areas of the country. However, when it grows on a steep roadbank to help prevent soil erosion it is not considered a weed. Generally though, weeds are defined as plants growing where they are not wanted.

Why control weeds? Weeds can cause economic losses in a variety of ways. Their most obvious effect on crops is a reduction in yield due to direct competition for soil moisture, nutrients and light. Beyond this, weeds may harbor pest insects, mites, vertebrates or disease agents. They can interfere with the planting, transplanting, thinning, harvesting and processing of crops. Some weeds may produce growth inhibitors which directly retard the development of crop plants. Crop quality can be affected. For example, weed seeds in cereal grains and in planting seed, can significantly reduce the value of these commodities and weeds in feed may cause off-flavors in milk. Still other weeds can be irritating or poisonous to man, livestock and wildlife.

Green plants are basic for life and are indispensable in man's environment. They are a complex life form that utilizes energy from the sun, combined with minerals, water, and carbon dioxide to provide food for man and wildlife, to beautify the landscape and to reduce soil erosion. Plants can be classified in several ways. The most commonly used method is according to life cycle. Weeds are classified as being annuals, biennials or perennials.

Weed Classifications

Annual Weeds - Annual weeds are those that live less than 12 months. Summer annuals germinate from seed in the spring, flower and produce seed during the summer and die in the summer or fall. They overwinter as seed and are most serious as a pest in spring seeded crops. They are best controlled in the seedling stage. Examples of summer annuals are: Russian thistle, pigweed, lambsquarter and wild oats. Winter annuals germinate from seed in the fall, overwinter as low-growing plants, flower and produce seed the next spring and then die. They are most serious in perennial crops such as hayfields. They are easiest to control in the seedling stage. Shepherd's purse and wild mustard are broadleaf winter annuals and downy bromegrass is a grassy winter annual.

Biennial Weeds - Biennial weeds live for two growing seasons. They germinate from seed in spring or summer and produce basal leaves and a fleshy tap root. These basal leaves are referred to as a rosette and are found only in biennial plants. Biennials overwinter in the rosette stage. The following year they flower, produce seed and then die. They are most serious as weed problems in pastures and hayfields and are best controlled during the first year of growth. Typical biennials are common mullin, burdock and bull thistle.

Perennial Weeds - Perennial weeds live for more than two years and may live almost indefinitely. While annuals and biennials reproduce only by seed, perennials may reproduce either by seed or vegetatively and frequently have stolons, rhizomes, spreading rootstocks, tubers and bulbs which may serve as both survival and reproductive structures. Perennials emerge either in spring or summer and don't normally flower during the first year. Their topgrowth freezes back each winter and survival depends on underground structures. Regrowth occurs the following year. Flowers and seeds are generally produced during the second season and thereafter. Perennial weeds are the most persistent and the most difficult to control.

Common Agricultural Weed Pests

Downy Brome

Downy brome, also called cheatgrass, downy chess and wild oats, is a winter annual that reproduces by seed. It germinates in the fall, lives over winter and produces a seed crop the following spring or early summer. However, it can also germinate in early spring if followed by frost and set seed the same year. Germination of the seed is usually high but seed may infest fields for several years because of undesirable germinating conditions. The seed germinates under conditions of cool temperatures and ample moisture. If soil moisture is adequate, it usually germinates in the fall.

The plant grows 6 inches to 2 feet high. The sheaths and leaves are covered with fine, soft hair. The head is branched and somewhat drooping. Mature plants turn purple or brownish in color. The seeds are long and flat with an awn about as long as the seed. It matures seed early, before most other grass species or crops.

Downy bromegrass is troublesome in winter wheat areas, summer fallow and on rangeland. The growth and spread of downy brome is encouraged by continous winter wheat cropping and the so called trashy fallow system of farming. Since downy brome and winter wheat are both winter annuals, downy brome is especially hard to control where winter wheat is grown either continuously or in alternate years without crop rotation. Also, the warm soil under trash left by surface tillage favors germination of downy brome. Surface tillage often does not disturb the soil enough to destroy this plant.

There are a number of cultural ways to help control downy brome. These include elimination of seed, tillage, crop rotation and mowing. Elimination of seed can be partially accomplished by cleaning up field borders and between small grain strips. Plants should be destroyed before they make mature seed. Perennial, cool season grasses such as crested wheatgrass or Russian wildrye can be planted in waste areas. All seed should be clean.

When tillage is used as a control measure, a good job should be done with the first summer fallow operation. Weeds not killed at this time may develop an extensive root system which may be difficult to kill later. The soil should be dry enough to provide for good weed kill. Close mowing will prevent seed production. Viable seeds will be produced if mowing is delayed more than one week after heading. Generally two mowings about two weeks apart are necessary. Waste areas can be burned.

Bull Thistle

Bull thistle is generally not a noxious weed and is not difficult to control. However, it is often mistaken for Canada thistle which is a noxious weed and at times very difficult to control. Bull thistle is a native of Europe and has spread to most parts of the world. It has become a nuisance in pastures, noncultivated fields, ditch banks and wasteland.

Bull thistle is a biennial plant which only reproduces by seed. It produces a taproot and a rosette of spiny leaves the first year. The second year it produces a stalk 2 to 5 feet high and very spiny leaves 3 to 6 inches long, lobed, rough, hairy, deep green on the upper side and woolly white underneath. The flower heads are 1 to 2 inches in diameter and nearly as high, solitary on the ends of the branches, bright purple and fragrant. Bull thistle is sometimes found in alfalfa, sweetclover and small grain seeds.

Most practices that will prevent seed production will control bull thistle. The plants will not survive in cultivated areas. Mow second year plants when the flowers are starting to appear. This will control the weed in pastures.

Field Bindweed

Field bindweed usually grows in patches but can also infest entire fields. The small, pink or white flowers vary in size up to 1 inch in diameter. They close in the evening and during rainy weather. The leaves are arrowhead shaped. Long, cord like roots grow out in all directions and form buds which send up new shoots. The seeds are produced in round capsules. They are about 1/5 of an inch long, dull black to dark brown, oval with one face convex and the other angled with flat sides and coarse surfaces. The seed may live in the soil for many years. Old patches should be watched for new seedlings.

Field bindweed is one of the most competitive of the perennial weeds. Crop yields can be reduced 30 to 50 percent in bindweed infestations. A two or three year food supply is stored in the extensive underground root system. This makes it hard to kill by cultivation because the roots will live as long as the food supply lasts. To control or eliminate field bindweed, combinations of intensive cultivation, selective herbicides, soil sterilants and competitive crops are usually more practical than the use of chemicals alone.

Canada Thistle

The flowers of Canada thistle are small (3/4 inch or less in diameter) and are light pink to rose purple in color. The leaves are dark green and very crinkly. Sharp spines are numerous on the outer edges of the leaves and on the branches and main stem of the plant. It is sometimes confused with some of the common thistles. Most of these are biennials and much easier to control. Bull thistle and several other common pasture thistles have a white cotton like material on the leaves and stems. Canada thistle is usually dark green but some varieties may be grayish-green.

Canada thistle emerges in April or May in most areas where it is found. It is best adapted to areas where summer temperatures are moderate. It does well in a wide variety of soils. Infestations are found not only in cultivated fields but also in pastures, rangeland, forests, lawns, gardens and wasteland. Because of its seeding habits, vigorous growth and extensive underground root system, control or eradication is difficult.

Canada thistle is difficult to control once it becomes established. Competitive crops such as alfalfa, winter wheat and seeded grass pastures compete with Canada thistle but will probably not eliminate it. Increasing seeding rates by one-half and fertilizing at heavier than usual rates will give thistles greater competition. Planting contaminated seed has helped spread this weed, so be sure to always use clean seed.

One season of intensive cultivation from spring until freeze will usually eliminate over 90 percent of Canada thistle. Cultivate every 14 to 21 days using a sharp duckfoot cultivator with at least three-inch overlap of shovels or blade type implement. Cut thistle plants no more than four inches below the surface. Persistence and proper timing are important. Additional control measures will most likely require the use of selective herbicides.

Wild Oats

Wild oat is an annual weed with growth habits similar to small grains. It usually matures somewhat earlier than most small grains and shatters before harvest. There are three major reasons why the wild oat plant is difficult to control: 1) it shatters it's seed before most grain crops are harvested, 2) the new seed crop has a high percentage of dormancy and 3) the seed is long lived in the soil (seeds in the soil may emerge over a period of up to ten years). Also, wild oat seeds are difficult to remove from small grain crop seeds. Depending on the degree of infestation, wild oats will reduce yields of wheat or barley up to 50 percent. A single wild oat plant can produce as many as 800 seeds which can remain viable in the soil for ten years or longer.

The use of weed-free seed, proper seedbed preparation, good crop rotations and sound soil management practices are the most effective means of preventing infestations of wild oats. Most wild oat infestations have started from planting contaminated small grain seed.

Do not plow seeds under in the fall that have shattered from the current crop. Wild oat seeds left in a field must go through an after-ripening period before they will germinate. Many go through this period if left on the topsoil through the winter but do not after-ripen if covered with soil in the fall. Those seeds which after-ripen during the winter do not readily germinate the next spring. This after-ripening period may vary from a few weeks to several years.

Delayed spring seeding is probably the second most effective control measure. Spring tillage before planting a spring crop kills many wild oat seedlings. Harrow and pack the soil early in the spring to induce early germination of wild oats.

Since wild oats and small grains have similar growth habits, a good cultural control method is to include crops in the rotation that do not have the same life cycle as the weed. Perennial forage crops, row crops and fall seeded crops are useful in preventing infestations of wild oats.

Johnsongrass

Johnsongrass is a stout, persistent, perennial plant with creeping rootstocks. It grows 3 to 10 feet tall, is smooth stemmed, erect and very leafy. It is adaptable to a wide variety of soils but grows best in fertile lowlands. Under certain conditions, Johnsongrass is poisonous to livestock. Young plants are generally more toxic than mature ones. Interruption of growth, as by frost or drought, tends to increase the poisonous properties of the plant.

Johnsongrass can be eliminated from land only if reinfestation by seeds is prevented. Until all grass plants are prevented from producing seed along ditches, fence rows, stream channels, etc., control practices will need to be repeated continually. Cultural methods of control usually are more practical and less expensive than herbicides. Combinations of cultural and chemical control methods have been used with success.

Cultural control will prevent Johnsongrass from spreading and will reduce stands 90 percent or more. Objectives for controlling Johnsongrass should be: 1) to weaken existing plants and kill their rhizomes (underground stems) and prevent formation of new ones, 2) to control seedlings growing from seed already in the soil, 3) to prevent seed production and 4) to plant noxious weed-free seed or seed free of hybrids.

Close mowing or grazing for two seasons, followed by plowing, will weaken Johnsongrass rhizomes and cause them to form near the soil surface and be relatively short and easier to kill with cultivation. The following season, plow and cultivate every two or three weeks or whenever leaf growth reaches 2 inches. Continue cultivation until freeze. Use an implement that will bring the rhizomes to the soil surface where they will dry. A springtooth harrow has been found more effective for this than a duckfoot or disk. It is best to cultivate when drying conditions are favorable. Properly fertilized and managed alfalfa provides good direct competition for stands of Johnsongrass. But Johnsongrass must be weakened first before a stand of alfalfa can be obtained.

Russian Knapweed

Russian knapweed is a perennial weed that is very difficult to control or eradicate once it becomes established. In thick patches, no crop will grow in competition with it. It will also invade native grass sods. Patches will spread in alfalfa fields but more rapidly in cultivated fields. Russian knapweed starts growth early in the spring. It normally emerges early in May and is full grown (1 to 3 feet) by June. The stems and leaves are covered with a short gray knap and have a very distinctive bitter taste. Lavender-rose or white flowers about 1/2 inch in diameter appear during June. They are similar to small thistle heads and are 3/8 to 1/2 inch in diameter. The rootstock is dark brown or black, woody and scaly. Russian knapweed spreads by underground root stocks and by seed.

Competitive crops are usually not effective for control of Russian knapweed. If smother crops are used, they should be tall, have the capacity to develop an early, dense spring growth and retain their vigor until frost. Perennial grass crops offer some competition but need heavy fertilization. One year of intensive cultivation, prior to seeding, will usually result in a better stand of grass. Combinations of cultivation, cropping and selective herbicides will reduce a stand 85 to 90 percent. The remaining 10 to 15 percent is difficult to kill.

Curly Dock

Curly dock, also called sour dock, curled dock and yellow dock, is a perennial that reproduces by seeds and shoots from the crown. It is a common weed in many areas, occurring mostly in low moist wastelands, hay meadows, pastures and lawns. The plant has a large, deep taproot which sends up a flowering stalk 2 to 4 feet tall every year. During the first year, the plant forms a dense rosette of leaves. After that it attains a height of 2 to 4 feet. The leaves are lance-shaped, bluish-green and prominently curly along the margins. The blades are 3 to 10 inches long and the stalk of the leaf 1 to 2 inches long. Large numbers of reddish-brown winged pods are produced on each plant. Usually three small, shiny, reddish-brown triangular seeds are produced in each winged pod.

Curly dock is a bad pest in clover and alfalfa fields grown for seed. It is difficult to separate from these crop seeds. In lawns and pastures, remove scattered plants, including the roots, with a hoe or shovel. Badly infested fields should be plowed and scattered plants should be mowed or plowed under before they set seed. Curly dock can be eradicated with tillage or any control method that prevents seed production.

Principles and Methods of Weed Control

Effective control of an individual species is dictated by its growth habits and reproduction methods. Stage of growth, soil type, climatic conditions, crop and species of weeds are important factors which influence control practices. Consideration of the location of the weed infestation such as cropland, rangeland, orchards, wasteland or industrial site further confounds the selection of proper control measures. Thus, it is important to recognize that weed control is complex and that basic principles should be utilized for maximum effectiveness in controlling weeds.

There are three basic methods of managing weeds: control, prevention and eradication. Control is the process of containing, limiting and reducing weed infestations, thereby minimizing the weeds competitive effect on a crop. Control is also a method of decreasing the detrimental effects of weeds to crops while considering the cost of the operation. The competitive damage to crops caused by allowing a few weeds to escape may be economically justified when considering the cost of obtaining complete eradication. The principle of control usually pertains to annual weeds in farm crops.

Six principle methods of control are:

a. Mechanical
   handpulling, hoeing and spading,
   tillage (disturbing root systems),
   mowing, and
   smothering
b. Cropping and Competition,
c. Biological Control,
d. Crop Rotation,
e. Chemical, and
f. Fire,
   searing,
   flaming crops

Mechanical Control

Mechanical control involves the use of tools to physically cut off, cover, or remove from the soil any plants that are not desired. Several methods are available. Hand pulling, hoeing, and spading are laborious and inefficient but effective methods of removing annual or biennial weeds. Most perennials are not effectively controlled by this method since they are capable of vegetative propagation from the root system.

Tillage with mechanical implements can be utilized in two ways: first it is effective on small annual weeds as a means of severing or covering the plants. When plants are larger, tillage effectiveness may be reduced. Second, tillage can be used to disturb perennial root systems. Cutting and disturbing the established roots can cause them to desiccate before they reestablish. However, multiple tillage operations are required to effectively control perennial weeds.

Mowing is a means of preventing seed production and reducing competition from weeds. Mowing is ineffective on low-growing plants. Multiple mowing of perennial weeds may serve to deplete the root reserves and result in the death of the plants. Removal of the top of plants by mowing can result in stimulating dormant buds which produce new stems.

Smothering can be accomplished by placing a barrier at the soil surface that plants cannot penetrate. If plants are unable to emerge into the sunlight, they will soon die from the lack of photosynthetic nutrition. This method of weed control is often utilized in high value crops and in flower gardens around the home.

Crop Competition

Crop competition as a method of weed control is based on the law of nature, "survival of the fittest." This is probably the cheapest and easiest method of controlling weeds. A crop will survive and flourish if it can compete more efficiently for sunlight, water, nutrients and space than the unwanted plants. The growth habits of the crop in relation to the weeds are important factors in developing a crop competition system. Early weed competition is usually more detrimental to a crop than later competition when the crop is well established.

Biological Control

Biological methods of control utilize natural predators of the undesirable plants but are harmless to the desirable plants. Insects, diseases, parasitic plants, selective grazing and competitive replacement plants are examples of biological control agents. Natural enemies which attack the plant result in a balance of nature which is a control program rather than a means of eradicating a weed species. After the undesirable plant is removed, the predator agent population decreases as a result of the elimination of the food source. The weed species may increase again until the biological predator population recovers sufficiently.

Climatic and environmental conditions are influential in the success of a biological predator for controlling weeds. The ability of the insect or organism to adapt to the environmental conditions of the host plant may be the most important factor in the success of the biological control program. Severe winters or prolonged drought may eliminate the predatory agent, whereas the plant species you want to control may survive.

Crop Rotation

Crop rotation can be a means of controlling weeds by providing a strong competitive crop on disturbed soil during all periods of a growing season. Weeds can flourish prior to crop establishment and after harvest. Early emerging crops can limit the growth of later germinating weeds. Farm managers should provide crop cover on cultivated areas during as much of the growing season as possible.

Fire

Fire is an effective tool for removal of vegetation from ditchbanks, road right-of-ways and waste areas. Intense heat can sear green vegetation which usually dries sufficiently in 10 to 14 days so that complete buring can be accomplished. Burning can kill small weed seeds on the soil surface and emerging weed seedlings. Selective flaming in corn is an effective method of controlling small annual weeds, but is less effective on perennial species. Several treatments are required to control perennial species.

Chemical Control

Chemicals (pesticides) are the most modern and efficient means for controlling unwanted plant species. Selective herbicides date back to the turn of the century but the greatest advances have occurred in the last three decades. It is important to realize that herbicides are a product of modern technology and a tool for controlling weeds. The use of pesticides is not a replacement for good management practices and conscientious farming.

Types of Herbicides

Selective Herbicides - Selective herbicides are chemicals which can remove certain plant species with little or no damage to other species. Selectivity is usually obtained as a result of the way the herbicide is used. The selectivity of a chemical is not absolute and may depend on the following:

a. The amount of chemical applied,
b. The way it is applied,
c. The degree of wetting the foliage,
d. The precipitation following treatment,
e. The ability of a plant species to tolerate a specific herbicide, and
f. Differences in growth habits of crops and weeds.

Since selectivity of a herbicide can depend on all of the above factors, a herbicide may be utilized as a selective or non-selective treatment depending on intended use. Grass seedlings can be controlled by 2,4-D although the primary use of 2,4-D is the selective control of broad-leaved weeds in grass crops.

Foliage treatments are herbicide applications to the leaves of growing plants usually as sprays, mists or dusts. There are two basic types of selective herbicides used in foliage treatments: contact and translocated.

Contact Herbicides - Contact herbicides are chemicals that do not translocate or move in the plant. This group of herbicides kill only the plants or portions of the plant actually contacted by the pesticide. In order to obtain effective control, adequate distribution or coverage on the foliage is essential. This can be accomplished by using high volumes of carrier or diluent to apply the herbicide.

Translocated Herbicides - Translocated herbicides are pesticides that move within a plant once the material is absorbed into the tissue. The greatest amount of transport is through the vascular system of the plant. Translocated herbicides may be effective in destroying roots of perennial plants.

Soil treatments are herbicide applications to the soil. To be effective, the herbicide must be carried into the soil by sprinkling or rainfall in order to be absorbed by the root system of the plant. There are several types of soil treatments: preplant, preemergence, and postemergence.

Preplant herbicide application is done prior to planting a crop. Preemergence is application after planting the crop but prior to the crop or weed emergence. Postemergence is application after both the crop and weed have emerged. The type of soil application you should use will depend on the crop being grown and the weed(s) you are trying to control. You should consult your local extension service agent for advice on your specific needs.

Non-selective Herbicides - Non-selective herbicides are pesticides which are toxic to all plants. They may be used to remove a wide range of vegetation from an area. When no selectivity is intended, these compounds can be utilized to control vegetation along fence rows, around pipe lines, traffic signs, storage areas and parking lots.

As with selective herbicides, non-selective herbicides can be applied to the foliage or soil. There are non-selective contact or translocated herbicides used to treat the plant's foliage. Generally non-selective herbicides applied to the soil include a wide variety of soil fumigants and soil sterilants.

Soil Fumigants - Soil fumigants are non-selective compounds which vaporize in the soil and kill seeds in the soil. They are relatively short-lived in the soil and crops can be replanted within a month or less without toxic effects. Vapam and methyl bromide are examples of soil fumigants.

Soil Sterilants - Soil sterilants are classified as: non-residual, temporary, semi-permanent and permanent. Non-residual treatments kill all green plant life and last for one or two days. Steam heat is the only non-residual sterilant. Tempertures of 212^{o} or greater for 30 minutes will kill weed seeds and plant roots. Temporary sterilants kill all green plant life but lasts four months or less. Semi-permanent treatment kills all green plant life but persists for four months to two years. Permanent sterilants kill all green plant life for more than two years.

The length of time the soil remains sterile depends on the following:

a. Classification of the sterilant,
b. Herbicide used,
c. Rainfall,
d. Application rates, and
e. Soil type and composition

Prevention is the most practical method of controlling weeds. If no weeds are allowed to infest a field, there is no problem with control measures. However, the task of implementing an effective prevention program requires extreme caution and alertness.

Rules of prevention weed control are:

a. Use clean seed,
b. Do not feed screenings, grain or hay containing weed seeds without first destroying their viability by grinding, cooking or ensiling,
c. Do not use manure unless the viability of weed seeds has been destroyed,
d. Do not permit livestock from weed infested areas to move directly to clean areas,
e. Clean harvesters, cleaners, balers, disks, plows and other implements before moving to other areas,
f. Avoid use of sand, gravel and soil from infested areas,
g. Nursery stock should be inspected for presence of weed seeds and tubers and rhizomes of perennial weeds,
h. Keep banks of irrigation ditches free from weeds,
i. Keep fence corners, fence lines, roadsides and all other uncropped areas weed free, and
j. Prevent the production of wind-borne weed seeds on any area.

Eradication is the complete elimination of all live plants, plant parts and seeds of the target species from an area. True eradication may be difficult since living plants and seeds (source for infestation) must be exterminated. Eradication is justified under conditions where small areas are infested with perennial weeds. Soil sterilization techniques can be used for complete elimination of green plants.

Weed seed contamination of the soil makes eradication nearly impossible in one season. Eradication programs should be designed to extend over several growing seasons to assure that all germinating seeds and seedlings have been killed. The development of selective herbicides in recent years has facilitated eradication of some perennial species without denuding the area of vegetation.

PLANT DISEASES

Plant disease agents have probably had a greater influence on the course of human history than any other of the agricultural pests. For centuries living organisms destroyed man's crops while he remained ignorant of their very existence. As late as 1846, people were offering what in retrospect appear to be outlandish explanations for the Irish potato famine. It was not until the late 19th century that any real understanding of the nature and causes of plant disease began to emerge.

The living organisms that cause plant disease were difficult to characterize simply because they are exceedingly small. Their discovery and identification as disease agents awaited the invention of the microscope and the development of modern scientific principles.

What is a plant disease? There are many definitions of a plant disease. However, the most commonly accepted definition for a plant disease is any harmful condition that makes a plant different from a normal plant in its appearance or function. Plant diseases are divided into two groups: non-parasitic and parasitic.

Non-parasitic plant diseases are caused by non-living agents. They cannot be passed from one plant to another. Examples of non-parasitic plant diseases include:

a. Nutrient deficiency,
b. Extreme cold or heat,
c. Toxic chemicals (air pollutants, salts, too much fertilizer),
d. Mechanical injury, and
e. Lack of or too much water.

Some non-parasitic plant diseases cannot be controlled very readily by man. Examples are extreme heat or cold. However, many other non-parasitic diseases such as nutrient deficiency, mechanical injury and too much fertilizer can be controlled by the use of proper farm management practices.

Parasitic plant diseases are caused by living agents which live and feed on or in the plant. They can be passed from one plant to another. The most common causes of parasitic plant diseases are:

a. Fungi,
b. Bacteria,
c. Viruses, and
d. Nematodes.

Insects can be another cause. A few seed-producing plants and some microbes can also cause plant diseases.

Three things are required before a parasitic disease can develop:

a. A susceptible host plant,
b. A parasitic agent, and
c. An environment favorable for parasite development.

Fungi are plants that lack green color (chlorophyll). They cannot make their own food. There are more than 100,000 kinds of fungi. Not all are harmful and many are helpful to man. Many are microscopic, but some, such as the mushrooms, may become quite large. Most fungi reproduce by spores, which function about the same way seeds do. Fungi may attack a plant both above and below the ground. Fungal diseases include apple scab, anthracnose of beans, smut in corn and powdery mildew on landscape plants.

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

Viruses are so small that they cannot be seen with the unaided eye or even with an ordinary microscope. They are generally recognized by their effects on plants. Many viruses that cause plant disease are carried by insects. Viruses are easily carried along in bulbs, roots, cuttings and seeds. Some viruses are transmitted when machines or men touch healthy plants after touching diseased plants. A few are transmitted in pollen. At least one virus is transmitted by a fungus. A few are transmitted by nematodes. Wheat streak mosaic and corn dwarf are diseases caused by viruses.

Nematodes are small, usually microscopic, roundworms. They are also called eelworms. Many nematodes are harmless. Others may attack crops planted for food, fiber or landscape purposes. Some species attack the above ground plant parts such as leaves, stems, and seeds. Most species feed on or in the roots. They may feed in one location or they may constantly move through the roots. Nematodes usually do not kill plants but reduce growth and plant health. They may weaken the plant and make it susceptible to other diseases.

All nematodes that are parasites on plants have a hollow feeding spear. They use it to puncture plant cells and feed on the cell contents. Nematodes may develop and feed either inside or outside of a plant. Their life cycle includes an egg, four larval stages, and an adult. Most larvae look like adults but are smaller. The females of some become fixed in the plant tissue. Their bodies become swollen and rounded. The root knot nematode deposits its eggs in a mass outside of its body. The cyst nematode keeps part of its eggs inside its body after death. They may survive there for many years.

Development of Plant Diseases

A parasitic disease depends on the life cycle of the parasite. The environment affects this cycle greatly. Temperature and moisture are especially important. They affect:

a. The activity of the parasite,
b. The ease with which a plant becomes diseased, and
c. The way the disease develops.

The disease process starts when the parasite arrives at a part of a plant where infection can occur. This step is called inoculation. If environmental conditions are good, the parasite will begin to develop. This stage before injury develops 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 parasite.

The three main ways a plant responds are:

a. Overdevelopment of tissue, such as galls, swellings and leaf curls,
b. Underdevelopment of tissue, such as stunting, lack of chorophyll and incomplete development of organs, and
c. Death of tissue, such as blights, leaf spots, wilting or cankers.

Control of Plant Diseases

The ultimate concern about a plant disease is to reduce or eliminate the economic or esthetic loss it causes. This is called the control of a disease. Plant disease control involves one or more of three basic principles: exclusion, protection and resistance.

Exclusion involves measures to prevent a disease organism from becoming introduced into and established in an area where it does not naturally occur. Plant quarantines are one means of exclusion.

Protection involves the use of plants that are not susceptible to the disease. Immunity is the ultimate degree of resistance and is usually not obtained in genetic programs aimed at developing resistance in a given plant. The level of resistance may vary considerably depending on a large number of factors, such as age of the host plant, aggressiveness of the pathogen, relative favorability of the environment, etc. Very often a plant variety or selection that is resistant to disease lacks desirable qualities wanted for commercial purposes.

The two main ways of controlling plant diseases are the use of plants which are resistant to various plant diseases and the use of pesticides. Pesticides are designed to stop the growth of pathogens on or within host plants and to protect healthy plants from pathogens that attempt to attack them. However, pesticides used for plant disease control do not destroy the pathogen, they only probibit the disease from further attacking a plant.

VERTEBRATES

Agricultural problems with vertebrate pests - rodents and those species generally considered "wildlife" - rarely approach the magnitude of the problems caused by weeds, insects, diseases and weather. Under certain circumstances, however, and particularly for individual growers, vertebrate pest problems can be significant and difficult to deal with.

There are a number of factors which complicate the control of vertebrate problems. For example:

a. Mobility: Certain mammals and birds may come from long distances to damage agricultural crops. Thus, they may spend most of their time on private or public land where they are not a problem.

b. Unpredictability: There are many factors such as population density, weather and availability of natural food which influence the transition of a normally harmless vertebrate population into the role of a pest.

c. Public Perception: Most vertebrates, especially larger ones such as geese or deer, are held in high esteem by the public. Efforts to control them can then become a complex social problem as well.

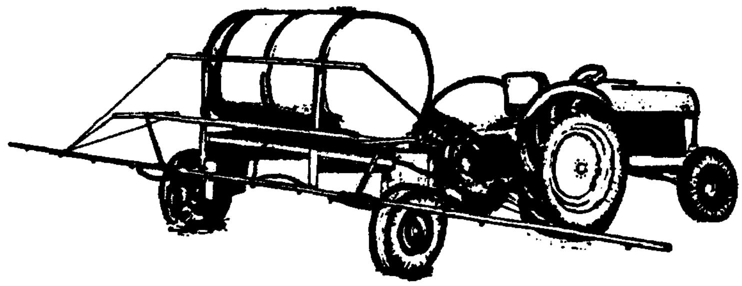
d. Legal Status: Most mammals and birds enjoy some protection under state and/or Federal law as game animals, migratory birds or endangered species. Only a relative few are unprotected or covered under "about to damage" provisions. Thus a grower needs to be well aware of the species involved in damage and the legal or permit requirements relative to it.

e. Control Techniques: Often because of environmental complications or the legal status previously mentioned, broadcast chemical controls are not as readily available for vertebrate problems as for weeds or insects. Control may center on cultural practices or physical barriers.

Due to the many variables involved in controlling vertebrate pests, you should contact your local county extension agent, state department of agriculture or the U.S. Fish and Wildlife Service for specific recommendations in identifying and controlling vertebrate pests in your area.

CHAPTER 6

APPLICATION EQUIPMENT AND CALIBRATION



The choice of appropriate application equipment and its proper operation and maintenance are perhaps as important to effective pest control as 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 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.

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 to be used, available application equipment and the relative cost and efficiency of alternative methods. Although there is frequently a choice between two or more methods, the method of application is often predetermined by one or more of these factors. Always bear in mind that your principal objective is to effectively bring the pesticide into contact with the target organism.

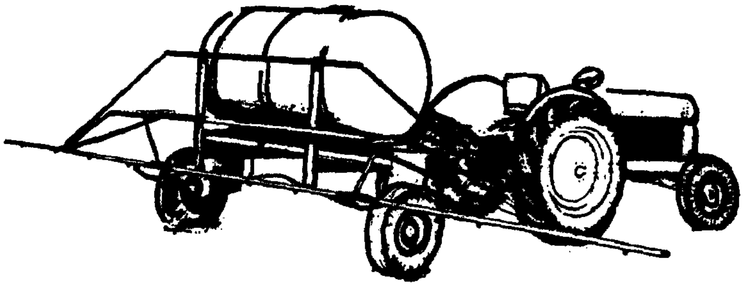
Common methods of application of pesticides to crops are outlined below:

a. Foliar application is application of a pesticide to the aerial portions of either a crop or a weed,
b. Soil application is application of a pesticide directly to the soil rather than to a growing crop or weed,
c. Seed treatment is coverage of seed with an insecticide and/or fungicide prior to planting,
d. Broadcast application is the uniform application of a pesticide to an entire field or area. It can be either prior to or after emergence of the crop,
e. 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,
f. Furrow application is the placement of an insecticide or 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,
g. A split-boot application is the placement of a mixture of liquid insecticide and liquid 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,

h. Spot treatment is application of a pesticide to small discrete areas,
i. A directed-spray application is directed specifically at target weeds in an effort to minimize contact with the crop,
j. Soil incorporation is the use of tillage implements to mix the pesticide with the soil,
k. Soil injection is application of a pesticide beneath the soil surface.

Types of Ground Application Equipment

Low Pressure Boom Sprayer

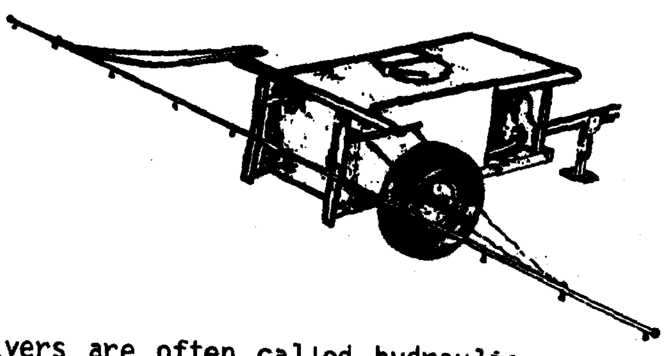


These sprayers are usually mounted on tractors, trucks or trailers. They are designed to be driven over fields or large areas of turf, applying the pesticides in swaths to the crop. Low pressure sprayers generally use a relatively low volume of dilute spray ranging from 10 to 40 gallons per acre applied at 30-60 lbs. pressure. They usually have roller type pumps that limit their pressure to about 80 lbs./square inch. Handguns can be attached for remote spraying for spot treatment and patches of weed infestations.

Advantages: Low pressure sprayers are relatively inexpensive, light weight, adapted to many uses and can cover large areas rapidly. They are usually low volume so that one tankful will cover a large area.

Disadvantages: Low pressure sprayers cannot adequately penetrate and cover dense foliage because of their low pressure and gallonage rate. Because they must rely on bypass systems and return flow agitation, wettable powder formulations often settle out. However, if mechanical agitators are used, this is not a problem.

High Pressure Sprayers

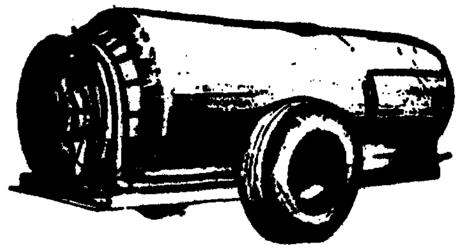


High pressure sprayers are often called hydraulic sprayers. They operate with dilute sprays, and pressures can be regulated up to several hundred pounds. They are used for spraying shade trees, livestock, orchards, farm buildings and unwanted vegetation where dense foliage requires good penetration.

Advantages: High pressure sprayers are useful for many different pest control jobs. They have enough pressure to drive a spray through heavy brush, thick cow hair or to the tops of tall shade trees. Because they are strongly built, they are long lasting and dependable. Piston pumps are standard and resist wear by gritty or abrasive materials. Mechanical agitators are also standard and keep wettable powders well mixed in the tank. With a long hose and handgun, trees, shrubs or other targets in hard to get at places can be treated.

Disadvantages: High pressure sprayers are heavy and costly. They usually use large amounts of water and thus require frequent filling.

Air Blast Sprayers



Practically all spraying in commercial orchards and much of the spraying on shade trees is with air blast sprayers. Air blast sprayers are primarily designed to carry pesticide/water mixtures under pressure from a pump through a series of nozzles into a blast of air that blows into the trees by means of a fan. High volume fans supply the air which is directed to one or both sides of the sprayer as it moves between rows of trees. Nozzles operating at low, moderate or high pressure deliver the spray droplets into the high velocity air stream. The high speed air aids in breaking up larger droplets and transporting these smaller droplets for thorough coverage. Agitation of the spray material in the tank is usually accomplished with a mechanical agitator.

Advantages: A small amount of water covers a large area and very little operating time is lost in refilling. They are usually less tiring to operate than hydraulic sprayers and are particularily adapted to applying sprays over a large area.

Disadvantages: Since the pesticide is carried by an air blast, these types of equipment must operate under calm conditions. Windy conditions interfere with the normal pattern of application of the blower. The sprayers are normally large and can not get to a lot of hard to get at areas.

Granule Spreaders

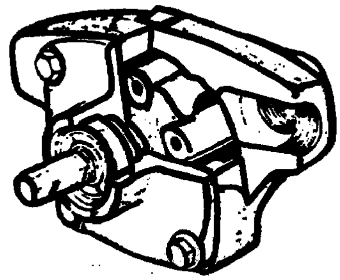
Granular equipment is designed to apply coarse, dry particles that are uniform in size to soil, water, and foliage. Spreaders may work in several different ways including air blast, whirling disks, multiple gravity feed outlets and soil injectors. They may be broadcast or band spreaders.

Advantages: Granular equipment is light, relatively simple and no water is needed. Because granules are uniform in size, flow easily and are relatively heavy, seeders and fertilizer spreaders can be used to apply granules, often without any modifications.

Disadvantages: Because granular materials do not generally stick well to foliage, granule spreaders are not usually used on plants. Therefore the applicator will need other types of application equipment for controlling most leaf-feeding insects and most plant diseases.

Sprayer Components

Pumps



The ideal pump for sprayers should deliver the recommended spray dosage at the required pressure and should have an economical service life.

Piston Pumps

Piston pumps are positive displacement pumps that can be used to apply both corrosive and abrasive materials. There are two types: High pressure-low volume-high speed and low pressure-high volume-low speed.

Gear Pumps

Gear pumps are semi-positive pumps that develop uniform, moderate pressures but are limited in volume of output. They are not used with abrasive materials.

Roller Impeller Pumps

Roller impeller pumps are adaptable to a wide range of pressures, volumes and materials. This type is accurate in amount and placement of spray material because it maintains constant pressure and flow.

Centrifugal Pumps

Centrifugal pumps are designed to handle abrasive and coarse materials. Pumping action is accomplished by a high speed impeller that throws the material out of the pump. It is used to spray high volumes at low pressures.

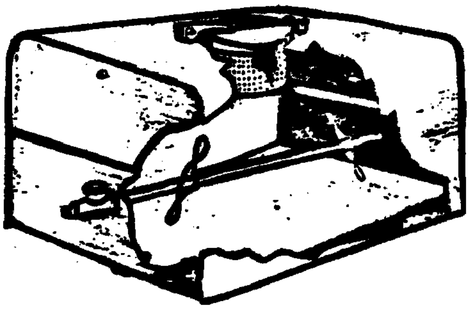
Tanks

Many spray materials are corrosive to metals and the resulting rust and scale will plug the system's filters, cause excessive wear on the pump or clog the nozzles. Tanks made of plastic-lined steel, stainless steel or fiberglass are preferred materials because they are more durable and will be more practical and economical over a long period of time. The inside corner

The tank may be of any size but should be matched to the type of job the sprayer will be expected to perform. The capacity will depend on the size of pump used and the availability of the water for mixing. Commercially available units generally hold 10 to 20 times the per minute output capacity of the pump. (Example - 20 gallons per minute pump - 200 to 400 gallon tank)

Sprayer tanks should have a large, covered opening in the top fitted with a removable strainer for ease of filling, inspection and cleaning. A drain plug should be provided in the bottom to permit complete drainage when cleaning.

Agitators



Make sure your sprayer has adequate agitation or your actual pesticide application rate may vary greatly as the tank is emptied. By-pass agitation is accomplished by pumping excess spray material back into the tank under pressure. Mechanical agitation utilizes paddles or impellers. Jet agitation utilizes the spray material from the system, pumped under pressure through a jet nozzle. Mechanical agitation is the surest means of getting good agitation but is expensive initially and harder to maintain. By-pass agitation may be sufficient for solutions and emulsions but for wettable powders a separate jet agitator should be used.

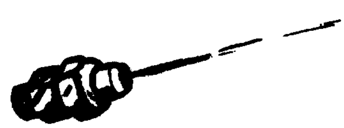
Nozzles

Nozzles used for a boom, hand-gun or broadcast type application control the amount of pesticide applied, uniformity of application, thoroughness of coverage and degree of safety. Nozzles should be selected to provide proper droplet size and application rate within the required range of pressure.

There are five basic nozzle types:

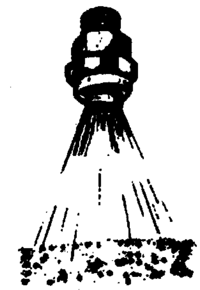
Solid Stream

The solid stream nozzle is a type used in hand-guns to spray a distant target and for crack and crevice treatment in buildings. Also a type used in a nozzle body to apply pesticides in a narrow band or inject them into the soil.



Flat Fan

There are three types of flat fan nozzles: The regular flat fan nozzle makes a narrow oval pattern with lighter edges. It is used for broadcast spraying. This pattern is designed to be used on a boom and to be overlapped 30-50 percent for even distribution.

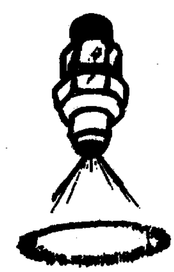


The even, flat fan nozzle makes a uniform pattern across its width. It is used for band spraying and for treating walls and other surfaces.

The flooding nozzle makes a wide-angle spray pattern. It works at lower pressure than the other flat fan nozzles. Its pattern is fairly uniform across its width. It is used for broadcast spraying.

Hollow Cone

There are two types of hollow cone nozzles: the core-disk and the whirl chamber. The pattern is circular with tapered edges and little or no spray in the center. It is used for spraying foliage.

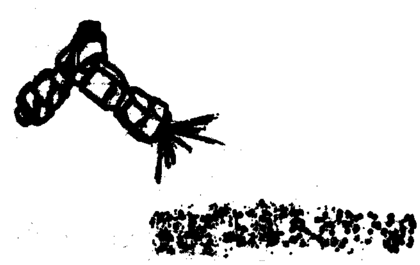


Solid Cone

This nozzle produces a circular pattern. The spray is well distributed throughout the pattern. It is used for spraying foliage.

Broadcast

This nozzle forms a wide flat fan pattern. It is used on boomless sprayers and to extend the effective swath when attached to the end of a boom.



Many spraying jobs can be done by more than one nozzle type of pattern. Here are some general guidelines:

For Weed Control:
regular flat fan,
flooding fan,
even flat fan, and
hollow cone.

For Disease Control:
hollow cone, and
solid cone,

For Insect Control Outdoors:
regular flat fan,
hollow cone, and
solid cone.

For Insect Control Indoors:
even flat fan,
solid stream, and
atomizing.

To Minimize Drift:
flooding fan,
whirl chamber hollow cone, and
keep operating pressure below 30 psi.,

You can get nozzles in many materials. Here are the main features of each kind:

Brass:
inexpensive,
wears quickly from abrasion, and
probably the best material for limited use.

Stainless Steel:
will not corrode,
resists abrasion, especially if it is hardened, and
expensive.

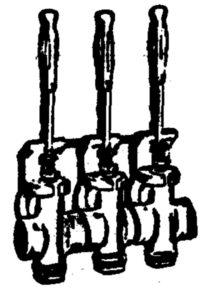
Plastic:
resists corrosion and abrasion, and
swells when exposed to some solvents.

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

Tungsten Carbide and Ceramic:
highly resistant to abrasion and corrosion, and
expensive.

Keep nozzles in good working condition. For most boom applications, select nozzles of uniform type and size. Nozzle caps should not be overtightened. Adjust nozzle distance and spacing to suit the target. Follow the nozzle instructions and the pesticide label. Allow for crop or weed height if using water and a jar marked in ounces. Replace any nozzles having faulty spray patterns. A good check is to spray on asphalt pavement. Watch for streaks as you increase speed or as spray dries. Clean nozzles only with a toothbrush and wooden toothpick. Any nozzle which shows a variation of more than 5 percent from the average of all the nozzles should be changed.

Maintenance of Equipment



Periodic inspections and frequent lubrications will reduce labor costs and breakdowns and prolong the life of the pump and sprayer. Before using a new sprayer or one that has been idle for awhile, flush it with clean water. This will remove all metallic chips sometimes found in new sprayers, and rust and dirt from idle sprayers. Remove and clean all screens and nozzles before spraying.

Use only clean water in your sprayer. The cleanest source is from a well or city hydrant. Water from other sources should be filtered to help prevent any damage to your equipment.

Sprayers should be thoroughly cleaned inside and out after each day's use to prevent corrosion and accumulation of chemicals. The cleaning water should not be discharged where it will contaminate water supplies, streams or crops, or puddle to injure livestock, humans or wildlife. The strainers, screens and nozzle tips should be periodically inspected and cleaned.

Cleaning equipment prior to storage at the end of the spray season is important and should be done in the following manner:

Step 1: Hose down the inside of the tank completely, fill to half full and flush the pumping system through the nozzles by operating the sprayer. Be sure to dispose of your flushed material in a safe and proper manner.

Step 2: Repeat Step 1.

Step 3: Remove nozzle tips and screens. Clean them with a soft brush in kerosene or a detergent/water mixture.

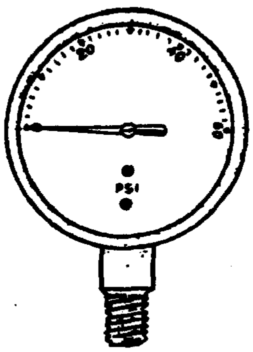
Step 4: Fill the tank half full and add one pound of detergent to every 50 gallons of water. Circulate the mixture through the by-pass pressure regulator and jet agitator if used and then flush it out through the nozzles.

Step 5: Replace the screens and nozzle tips and refill the tank about one-half full of water. Add one quart of household ammonia to each 25 gallons of water. Circulate this mixture through the system for 5-10 minutes, allowing some to go through the nozzles. Keep the remainder of the solution in the system overnight and then run it out through the nozzles.

Step 6: Flush the system with the tank one-half full of clean water by spraying through the boom and nozzles.

Step 7: Remove nozzle tips and disks, strainers and screens and store in light oil. Store sprayer in a clean, dry structure. If the pump cannot be drained completely, store it where it cannot freeze. Oil films should be applied to some types of tanks and possibly to pumps to prevent rusting. Check your equipment manual for specific instructions.

Calibration of Equipment



The application of the right pesticide, at the right time and at the proper rate is important to prevent contamination of the environment. To get the correct rate, application equipment must be properly adjusted and operated. Accurate calibration of the equipment is important. Applying too little will not control the pest and too much may injure the crop being treated or damage the environment.

The are a number of variables affecting application rates: These include:

Speed - The speed a sprayer travels must be determined accurately and held constant both when calibrating and actually applying the pesticide. Changing the speed will change the output of the equipment. To determine the speed of your sprayer, you should follow these steps:

Step 1: Set two markers in the field 88 feet apart (88 feet is 1/60 of a mile),
Step 2: Select the gear and throttle setting on your equipment,
Step 3: From a running start, check the time in seconds required to drive the 88 feet course, and
Step 4: Divide 60 by the time in seconds required to drive the 88 feet. This will be your field speed. (Example: 15 seconds to drive 88 feet. 60 divided by 15 equals 4 miles per hour).

Pressure - The rate of flow of spray material relates directly to pressure and should be held constant. Increasing the pressure increases the output while less pressure decreases the output. To double the spray output, you must increase the pressure four times. (Note: Applying pesticides at high pressures produces smaller droplets, therefore, increasing the possibility of drift).

Nozzle Openings - The nozzle opening determines rate of application when pressure is held constant. The larger the opening, the greater the amount of spray material applied. The shape of the opening determines the spray pattern.

Nozzle Spacing - Most sprayers have fixed nozzle spacing. If nozzles are adjustable, moving them closer together will increase the amount of spray applied per acre. Moving them further apart will decrease the amount applied. Moving nozzles may also affect uniformity of the spray pattern.

Nozzle Wear - Sprayers cannot be accurately calibrated if nozzles are worn. Abrasive solutions such as wettable powders can cause nozzles to wear rapidly. Equipment should be calibrated more frequently when using wettable powders.

Viscosity - Sprayers are usually calibrated with water. If the viscosity of the spray material is considerably different than water, calibrate with the liquid that will be used in spraying.

Pre-calibration Check

Several methods can be used satisfactorily to calibrate a sprayer. Select the method that suits you best. Before calibrating, make the following inspections:

a. Check the operating parts of your sprayer,
b. Be sure nozzle tips and screens are clean,
c. Be sure nozzle tips and screens are the correct size and shape for the job, and
d. Check for nozzle wear by determining output of each nozzle.

Calibration Methods

Broadcast Spraying

a. Jar Method - Pre-calibrated jars may be obtained commercially. Lay out a short, measured course, attach the jar under a nozzle and drive the course at a certain speed and pressure. The application rate in gallons per acre can be read directly from the jar.

b. Total Volume Method - After operating the sprayer to fill the supply system up to the shut-off valve, fill the tank to the top . Select an area for a test run that is similar to the area to be treated. Measure off 1/8 of a mile (660 feet) and spray the test run at the speed and spray pressure that will be used when spraying. Measure the amount of water (or spray solution) used by refilling the tank to the starting level. The amount applied per acre can be determined by multiplying the number of gallons used by the factor 66 and dividing by the width of the swath (boom). Example: Gallons used times 66 divided by swath width equals gallons applied per acre. (5 gallons (used) times 66 divided by 20 feet (swath width) equals 16.5 gallons per acre.)

c. Nozzle Volume Method - Select a container calibrated in ounces or cups or plastic bags to collect spray material from the nozzles. Fill the tank one-half full or more with clean water and drive a measured distance (660 feet) by turning the sprayer on at the start and off at the finish. Accurately measure the water collected from one nozzle or the average of several nozzles and multiply by the number of nozzles on the boom for the total volume or measure total discharge from all nozzles on the boom. Calculate the number of gallons applied per acre by multiplying the number of gallons used by the factor 66 and divide by the width of the swath (boom).

Band Spraying

Band application where only a part of the total area is sprayed can be determined by measuring off a distance (300 feet) and calculating how much is used to spray this distance. Calculate the gallons per acre by the following formula:

$$\frac{\text{43,560 (Sq. Ft./Acre) X Gallons Used}}{\text{Distance Traveled (Ft.) X Band Width (Ft.) X Number of Bands}} = \text{GPA}$$

Example: 1/2 gallon of spray material was used to spray 300 feet using two nozzles each spraying 12 inch bands.

$$\frac{\text{43,560 Sq. Ft. X 0.5 Gal. Used}}{\text{300 Ft. X 1 Ft. (12" Bands) x 2 Bands}} = \text{36.3 Gals./Acre}$$

Air Blast Spraying

Determine by trial the speed that provides the best coverage of the trees. The speed traveled in miles per hour can be determined by using a watch with a second hand and by determining the number of tree spaces traveled in a specific time. For example, if your tree spacing is 25 feet and you pass 7 tree spaces (175 feet) in one minute, you are traveling 2 miles per hour.

(175 feet in a minute X 60 minutes = 10,500 feet per hour.
10,500 feet divided by 5,280 feet per mile = 2 miles per hour.)

Determine how much spray (gallons) you want to apply per tree, traveling at two miles per hour. Make a trial run with your equipment in operation with determined nozzle rate, pressure and speed. Fill the tank with water and spray a pre-determined number of trees. Measure the amount of water used and determine the amount used per tree. By calculating the number of trees in one acre you can determine the amount of spray volume used to cover one acre. Add the amount of chemical recommended per acre to the volume of water used to cover one acre of trees.

Granular Application

Granular applicators may be calibrated by collecting granules from one delivery tube while covering a designated area. Use the same procedure as under the nozzle volume method for total average coverage. If granules are applied in bands, use the procedure designated under band spraying.

Chemical Calculations

After calibrating the equipment to apply the volume of spray desired to get good coverage, you must determine how much chemical to put in the tank to apply the correct dosage recommended on the pesticide label. To do this you must know the capacity of your tank and the recommended rate per acre. Most recommendations are made in pounds of active ingredient per acre.

Liquid Formulations

Determine the number of acres that can be sprayed with one tankful. This is found by dividing the capacity of the tank (in gallons) by the gallons applied per acre.

Example: Capacity of Tank - 200 Gallons
Volume of Spray Applied - 10 Gallons Per Acre
200 gallon tank divided by 10 gallons per acre equals 20 acres per tank.

Determine the amount of chemical to be added to the tank. This is found by multiplying the acres one tank will spray by the recommended rate per acre.

Example: 20 Acres Per Tank At 1 Pound Per Acre Recommended
20 Acres X 1 Lb. Per Acre = 20 Lbs. Per Tank

If the recommended rate of chemical is given in pounds per acre, the quantity of chemical (gallons per tank) can be determined by dividing the pounds active ingredient per tank by the pounds per gallon (concentration of formulation).

Example: 20 Pounds Per Tank - 4 Pounds Per Gallon (Pesticide Concentration)
20 Lbs. Divided by 4 Lbs. Per Gallon = 5 Gallons Per Tank

Wettable Powders and Granules

These materials have active ingredients expressed as a percentage of the total weight and may vary from 5% (Granular) to 80% (Wettable Powder) active ingredient. To determine how much formulation (commercial product) you need to apply to meet the recommended rate expressed in pounds of active ingredient per acre, the following formula is used:

Herbicide (5% granular) at 2 lbs. per acre

$$\frac{\text{2 lbs. per acre}}{.05\ (5\%)} = \text{40 lbs. per acre}$$

Insecticide (80% W.P.) at 2 lbs. per acre

$$\frac{\text{2 lbs. per acre}}{.80\ (80\%)} = \text{2.5 lbs. per Acre}$$

Solutions - Dilution by Parts

If a specific percentage solution is needed to treat a product or an area, the following procedure should be used in determining how to mix for that solution:

Dilution by Parts

Percent of pesticide concentration divided by solution required.

Example: 80% concentration (pesticide) - 5% solution required
80% divided by 5% = .80 divided by .05 = 16 parts finished product
16 parts = 1 part pesticide (80%) in 15 parts of water.

How many gallons of 50% pesticide must be added to 100 gallons of water to make a 5% solution?

50% (.50) pesticide divided by 5% (.05) solution equals 10 parts total finished product. Ten parts equals 1 part pesticide (50%) in 9 parts of water.

$$\frac{\text{1 part pesticide}}{\text{10 parts water}} = \frac{\text{amount of pesticide required}}{\text{100 gallons water}} = \text{10 gals. pesticide}$$

CHAPTER 7

APPLICATION OF PESTICIDES

Selection of Control Methods

The applicator must use every opportunity available to him to correctly identify a pest before any control methods are considered. If he chooses to use a pesticide, the identification of the pest is necessary to apply the recommmended pesticide.

It is also important to know what stage of growth and time the pest can best be controlled. Usually, a pest can be controlled best during one particular stage of development. The applicator should know this stage so the right kind of pesticide and proper formulation can be used to get the most effective control.

Is Control Necessary?

Control of a pest is not always necessary merely because damage shows up on trees, shrubs or crops. The damage may not be caused by insects or a disease. If an insect is present, it may be a beneficial species or, if it did damage, it may have already left the area and will cause no further damage. The damage also may have been caused late enough in the season so as not to have any great effect on the crop. The economics of control also must be considered.

Alternative Methods of Control

Must the control method be application of a pesticide? This question should be considered by all applicators. Other controls such as cultivation to control a weed, draining a breeding area to control mosquitoes, destroying (burning) new plant growth to control diseases or the use of certain insect species to control other insects are alternatives to the use of pesticides. A pesticide treatment is not always necessary or economical.

Integrated Pest Management System (IPM)

Integrated control involves two or more methods used to control a given pest. The important factor is to select the best combination of control alternatives available and organize them into a pest management system. Biological and chemical control methods have received the most attention in integrated systems but other methods can also be used with success. Cultural and physical-mechanical methods are also good tools to control pests.

Integrated management is an ecological approach to pest control. It stresses the management of pest populations rather than eradication. Under this system of control, it is recognized that crops can tolerate certain levels of pest infestation. The infestation must, however, be held within the economic threshold or pest population that can be tolerated without incurring economic loss.

Selection of a Pesticide

If the applicator decides, after identifying the pest and considering all available control methods, that a pesticide must be used to reduce the pest population, the right pesticide must be chosen for the job. When choosing a pesticide, an applicator must consider the following:

a. The pesticide's effectiveness against the pest,
b. Do the directions on the pesticide label meet the needs,
c. Will the pesticide be phytotoxic to the plants being treated,
d. What damage will the pesticide cause to non-target species, and
e. Is the equipment necessary to apply the pesticide available?

Mixing the Pesticide

Observe all safety instructions and mixing procedures. The applicator is most likely to be dangerously exposed to pesticides when mixing since he is handling the concentrated forms. It is especially important that all safety precautions called for on the label be followed during mixing.

It is equally important that the applicator follow mixing procedures listed on the label, especially when tank mixing two or more pesticides. Partially fill the tank with the carrier being used before adding the pesticide. Wettable powders should be mixed with water to form a slurry before they are added to a spray tank. When mixing wettable powders and emulsifiable concentrates, add the wettable powder in a slurry first. If a compatability agent is used to help suspend the mixture, it should be added before the pesticide.

Accessory Materials and Adjuvants

Pesticide action may be improved by addition of accessory materials and adjuvants. Diluents and carriers change the volume of the pesticide formulation. A solvent allows the pesticide to dissolve into a diluent or carrier.

Carrier - Carriers are added to pesticide formulations that are concentrated and not easily applied. It gives the formulation "body" and "surface" adequate for ease of application.

Diluent - Diluents are added to a formulation when it is more concentrated than the recommended application rate.

Solvent - Solvents are used when pesticide formulations are solid or extremely thick liquid. Solvents dissolve the pesticide into the diluent or carrier.

Adjuvants - Adjuvants are added to pesticide formulations to improve their mode of action. These substances may increase spreading properties, assist emulsification, increase toxicity, promote penetration of plant parts, reduce interfacial tensions and perform other related functions. Adjuvants are either incorporated into the pesticide formulation at the time of manufacture or may be added by the applicator under certain conditions.

There are three basic types of adjuvants:

a. Surfactants or Spreading Agents - These materials allow the pesticide to spread out over treated surfaces and assist in wetting dusty, waxy or greasy surfaces. These materials also reduce interfacial tension, allowing the pesticide to make contact with a solid surface and improve penetration of the chemical into plants or animals.

b. Emulsifiers or Emulsifying Agents - These agents are used to maintain the stability (the time it stays mixed) of an emulsion. An emulsifier couples oil and water together because it occupies the space between the oil and water and allows them to remain mixed longer. Soaps and detergents may serve as emulsifiers.

c. Sticking or Thickening Agents - Sticking agents help the pesticide spray stick to surfaces such as leaves. Thickening agents increase viscosity of the spray. They help spray stick to leaves and reduce particle bounce and run-off during spraying. The term spreader-sticker is commonly used.

Compatibility and Incompatibility of Pesticides

Application of one pesticide at a time has long been an established agricultural practice. Today, because of the high cost of application, pesticide applicators have begun mixing two or even several chemicals in their spray tanks. This approach is an attempt to control more than one pest with a single application. There are a number of problems associated with the mixing of pesticides. Some chemicals are not compatible when mixed.

Adverse Chemical Reactions:

a. Toxicity or efficacy of one or both compounds may be reduced or increased,
b. Precipitation may occur to clog screens and nozzles,
c. The phytotoxicity (plant injury) may increase, and
d. The total toxicity may be greater than the sum of the toxicity of each pesticide (synergism).

Incompatibility:

a. Physical - Two or more chemicals mixed together may cause excessive foaming, curdling or deposit of a gummy substance at the bottom of the tank,
b. Phytotoxic - Chemical reaction of some mixtures may cause unexpected injury to plants,
c. Placement - Mixing chemicals may alter their original formulation to such an extent the proper placement is not possible,.
d. Timing - When applying a mixture of two or more chemicals, it may be difficult to time the single application to the most susceptible stage of each pest,
e. Water - Water is the most common carrier for pesticides. Water hardness may alter the formulation to make application difficult or less effective.

Combination With Fertilizers

When mixing fertilizers with pesticides, problems may be experienced. Mixing simple fertilizers such as superphosphate or phosphoric acid with pesticides presents no real problems or incompatibility. Combining liquid fertilizers and pesticides can become quite complicated and special care should be taken when mixing them. The applicator should also make sure that the pesticide(s) label(s) do not prohibit mixing with other pesticides or fertilizers.

Synergism of Pesticides

Synergism is the property exhibited by some chemicals to greatly increase toxicity and possibly increasing the toxic life of another compound when the two are mixed together. When the total effect of two combined chemicals is greater than the effect that would be realized by application of the compounds separately, the result is called synergism. Synergism can greatly reduce the cost of application by increasing the effectiveness of the treatment but it may also increase the problem of toxicity to the applicator and non-target species.

Applying Pesticides

Pesticides should be applied in a manner that gives the best possible coverage with the least amount of drift. Correct selection of the application method and equipment will eliminate many of the problems associated with pesticide application.

Proper calibration of the equipment is necessary to ensure the correct amount of pesticide applied to the treatment area. The equipment used will depend on the pesticide formulation used or visa versa.

Timing and Frequency of Application

Proper timing of the application is extremely important for effective pest control. Chemical treatment may have little or no effect if the insect, weed or plant disease organism is not in the proper stage of development. Because of problems related to residual life, some pesticides cannot be applied more than once during a season and must be applied so as not to leave a residue at harvest time. Most pesticides have a waiting period for residue breakdown.

Effectiveness

Most pesticides on the market have a broad spectrum of control, meaning they control a wide variety of insects, pathogens or weeds. The selection of the pesticide that will most effectively control the pest with a minimum of health, safety and environmental hazards will result in greater application efficiency. The most effective pesticide is not always the least expensive or the most toxic.

Persistence

The ability of a chemical pesticide to persist in the environment is a prime consideration when selecting a pesticide. Persistence often is desirable because the longer the compound remains active in the treatment area the more effective and economical the control program. However, persistence can cause serious environmental damage and greater risk to public health and safety. Pesticides vary in persistence. Always select the one that will be the least persistent and still be effective.

Pest Resistance

Chemical treatment of pest populations will destroy most of the susceptible individuals leaving those that are resistant to the compound. Because of their resistance to a specific pesticide, a different class of chemical compound or another method of control must be used.

Climatic Factors

a. Rainfall - Rainfall can have both detrimental and beneficial effects on pesticide application. Detrimental effects include washing the pesticide off of surfaces, diluting the pesticide, reducing its effectiveness, excess soil leaching and increased potential of run-off leading to surface or ground water contamination. Beneficial effects include increased absorption of pesticide into plant or animal tissues, moving herbicides into plant root zones, removing waxes and dust to increase penetration and improving growth activity of plant for better translocation of the pesticide.

b. Humidity - High relative humidity increases the rate of pesticide absorption into plants and animals thus increasing its effectiveness. It also can have detrimental effects on humans or valuable plants and animals by increasing absorption.

c. Temperatures - High tempertures, associated with low relative humidity, result in decreased pesticide absorption rates into plants. High temperatures may result in increased absorption in animals. High temperatures can cause increased volatility in some pesticides, decreased effectiveness, adversely affect some adjuvants and increase the phytotoxicity.

d. Sunlight - Sunlight affects many pesticides by causing photochemical breakdown. Some compounds such as carbamates break down readily, thus reducing their effectiveness.

Drift

Pesticide drift has been identified as one of the principal concerns facing agriculture. Where significant drift occurs, it can damage sensitive crops, pose health hazards, contaminate soil and water in adjacent areas and cause considerable friction among neighbors. Although it is impossible to eliminate drift entirely, it can be reduced to acceptable levels.

Drift can be defined simply as the movement of pesticides through the air to non-target areas. There are two basic types of drift: particle and vapor.

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

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

Aerial applications are particularly susceptible to drift since the materials are released from greater heights and a greater percentage of smaller droplets are formed than with ground equipment. Factors that influence drift include particle size, specific gravity, evaporation rate, height of release, air movements, weather conditions and the aerodynamic forces created by the aircraft.

The rate of fall of particles through the air is affected by their size and specific gravity. Small, lightweight particles fall very slowly and are, therefore, more susceptible to drift. Oil droplets tend to drift farther than water droplets because they are usually lighter and smaller and thus remain airborne for a longer period. Using the same nozzles and the same spraying pressure, smaller droplet sizes are produced with oils than with water. In addition, the rate of evaporation of water based sprays is higher than that of oil based sprays for equal size droplets unless anti-evaporant materials are added to the formulation.

Weather conditions directly affect the direction, amount and distance of drift. Avoid applications when the wind is blowing toward susceptible crops or sensitive areas or when wind speed is in excess of limits stated on the pesticide label. You may have to stop operations until conditions change. Consult weather forcasts whenever possible. One danger is that unpredictable changes in air movement may occur and carry the drift in an unexpected direction.

During early morning and late evening, the difference in the air temperature at ground level and at some distance above ground is considerably less than during the middle of the day. As the gound warms up, the air temperature near the ground becomes significantly higher than the air above it. This warmer air rises and may set up convection and thermal air currents which lift small particles. These small particles may be carried some distance before they settle out. For this reason and because wind speeds are frequently lower, it is often better to apply pesticides either in the early morning or in the evening.

Calm conditions with a temperature inversion (ground air two to five degrees cooler than the air above) may result in the smallest spray droplets remaining suspended as a dense cloud in a layer of undisturbed air. The entire cloud may be moved out of the area before coming to rest and resulting in relatvely high drift deposits. It is particularly important to avoid aerial application when this condition exists. Sufficient turbulence should be present in the atomsphere to disperse clouds of small drops when the spray is applied.

Drift Control Measures

a. Use the lowest reasonable pressure,
b. Set the boom only as high as is needed for good coverage,
c. Leave an untreated border around the field,
d. Angle nozzles of ground sprayers slightly forward toward the ground in the direction of travel,
e. Where practical, use a nozzle type which produces the largest droplets at a given rate and pressure,
f. Use non-volatile or low-volatile formulations whenever possible,
g. Spray when wind speed is low,
h. Do not spray aerially during a temperature inversion,
i. Spray when adjacent susceptible vegetation is mature or not present, and
j. Use a drift control agent such as foams, invert emulsions or thickeners.

CHAPTER 8

PESTICIDES AND THE ENVIRONMENT

The Agricultural Revolution upset in some measure the so-called "balance of nature". With the cultivation of plants and the domestication of animals, man first began to significantly alter the environment to meet his own needs and objectives. Since that time, man's progress has depended largely on his ability to successfully control and manipulate his environment and to adapt its resources to his own ends. Man has succeeded in doing so with enormous benefits to mankind.

During the twentieth century, the rate of progress has increased tremendously. We have changed the world around us to a greater extent in the last eight decades than we had done in all of our previous history. The rate of change continues to increase today.

Until quite recently, we were able to ignore for the most part the long term consequences of our progress. Whatever harm we may have done to our environment has been largely ignored, either out of ignorance or by choice. We can no longer afford to be so naive. Changes now occur so rapidly and with a potential for consequences so far reaching that they threaten to outrun our ability to effectively deal with them or to examine their benefits and risks in a rational manner.

A legitimate concern for our environment can no longer be limited to those groups who have traditionally addressed environmental issues. We are all beginning to reap the harvest of our largely unrestrained exploitation of the world we live in. There is the potential for significant contamination of our streams and groundwater, erosion of our topsoil is increasing in many areas, and air pollution continues to be a serious problem in many areas. These are some of the environmental problems facing us. We must all try to do our part to help avoid contaminating the environment.

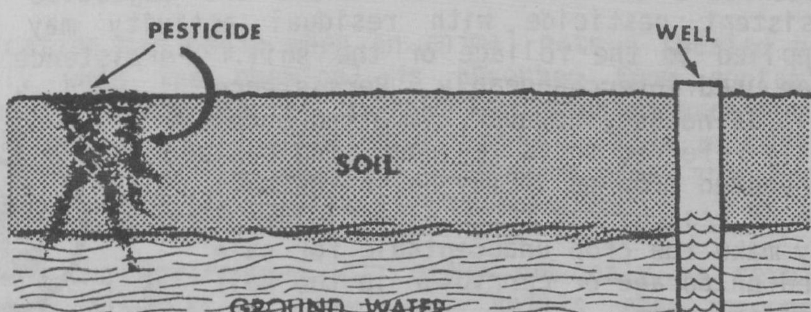
What is the Environment?

The environment is all of our physical, chemical and biological surroundings such as climate, soil, water, air and all species of plants, animals and microorganisms. Until just recently, most people viewed and studied the components of the environment largely as independent entities. Man obviously knew that climate had an effect on the distribution of species and that one organism could exert an effect on another but we were unaware of the complexity and extent of the interrelationships and balance that exists among all components of the environment. The branch of science which studies these interrelationships is know as "ecology".

This manual is concerned with the effects of pesticides on the environment. Pesticides are expressly designed to control those biological components of the environment we consider pests. They have the potential, however, to cause direct and immediate harm to living organisms other than those we wish to control as well as the potential for indirect or long term adverse effects on other components of the environment.

The fate of a pesticide in the environment begins with its initial distribution (application, disposal, spill, etc.) and continues through its subsequent movement, persistence and fate in each component of the environment. Studies have shown that a significant percentage of pesticides never reach the intended site of application either because of drift, volatility or misapplication. In a practical sense, it is impossible to completely eliminate either particle drift or volatility but it is possible to reduce them to acceptable levels. Where significant drift does occur, it can damage sensitive crops, pose health hazards, contaminate soil and water in adjacent areas and cause considerable friction among neighbors. Drift of insecticides and fungicides often goes undetected unless it occurs in sufficient quantities that the actual drift is visible or it leaves a noticeable residue. The effects of herbicide drift, on the other hand, are often readily apparent. Substantial injury may occur to susceptible plants in adjacent areas and perhaps even some distance from the application site. Drift and ways to reduce it were discussed in the previous chapter.

Once a pesticide reaches the target area, subsequent movement may occur in a variety of ways. It may volatilize from plant or soil surfaces, be moved by wind or water from treated foliage to the soil, be carried laterally by surface water runoff or through soil erosion, be incorporated into the soil with crop residues, be taken from the field as residue on the crop itself or be leached through the soil. Eventually, a large portion of the pesticides we apply end up in the soil. Ultimately, various amounts may find their way into surface waters or groundwater.

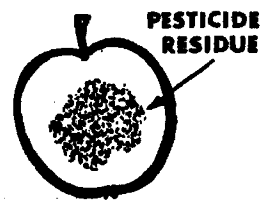


Many factors determine the extent of pollution which is likely to result from the use of a given pesticide. The method of application, the formulation, and the weather are important considerations. The properties of the pesticide itself are equally important. Pesticides vary in their degree of attachment or adsorption to soil particles. Those which are strongly absorbed are less likely to be carried from the treated area by surface water or leached through the soil into the groundwater. They may, however, be moved readily by soil erosion. Pesticides also vary in their degree of water solubility. Those with greater solubility have a greater potential for both water contamination and movement. The volatility of a pesticide is a measure of its tendency to turn into a vapor. Pesticides with greater volatility dissipate more rapidly and pose less risks of soil and/or water pollution.

An often critical factor in determining the extent of pollution is the rate of degradation or breakdown of the pesticide. Pesticides vary substantially in their susceptibility to degradation. Degradation may be either chemical, physical or biological or any combination of the three. The biological breakdown of a pesticide is the result of attack by fungi, bacteria and other microorganisms. Biological activity in the soil requires adequate soil moisture and temperature. The rate of degradation diminishes with decreasing soil moisture and literally ceases in very dry soils. Breakdown also decreases at lower temperatures and very little occurs during the cold winter months.

When a pesticide is degraded, it is changed chemically. It is usually, but not always, broken down into non-toxic compounds. For most pesticides, once degradation has proceeded to a sufficient extent, they are no longer active as pesticides and pose no further risks of pollution. While most degradation of pesticides occurs in the soil, breakdown may also occur in water or on soil or plant surfaces. All pesticides, including the chlorinated hydrocarbons, are subject to degradation. Only the rate of degradation varies. Although some pesticides may remain in the environment for years, none will remain forever.

Man frequently refers to the persistence of a pesticide. Persistence is simply a measure of how long a pesticide remains in an unaltered form at the site of application or in the environment. Persistence at the site of application is a function of a pesticide's adsorption, solubility, volatility and susceptibility to degradation. In other words, a pesticide may persist for only a short time at the site of application either because it is broken down or because it is carried elsewhere. Persistence at the application site may be either desirable or undesirable. Where the objective is long term control, a persistent pesticide with residual activity may be desirable whether it be applied to the foliage or the soil. Persistence and residual activity are often used interchangeably. Persistence beyond the time it is needed, however, is often undesirable and is usually referred to as residue. The residue may be on the harvested crop or it may be in the soil itself. Any type of residue can cause significant problems. It may make the crop unacceptable for sale or for use as feed or forage or carryover in the soil may affect succeeding crops.



In addition to the properties of the pesticide itself, weather and the rate of application can affect persistence at the site of application. Soil moisture and temperature have important effects on degradation. In addition, heavy rains or improper irrigation may wash pesticides off foliage and may cause excessive runoff and leaching. The rate of volatilization of a pesticide is dependent to some extent on temperature and humidity. Soil type may also be important. A clay soil normally adsorbs significantly greater amounts of a pesticide than a sandy soil. Leaching of highly soluble pesticides through the soil and into the groundwater can be a problem where soils are particularly sandy.

The persistence of a pesticide in the environment, rather than simply at the site of application is largely a function of its susceptibility to degradation. Its adsorption and solubility properties, as well as weather conditions, do affect its rate of movement away from the application site and its subsequent distribution. They also determine to some extent its availability for degradation. Ultimately it is the rate of breakdown which determines its persistence.

Those pesticides which are persistent may pose a greater risk of injury to non-target organisms, particularly fish and wildlife which may be exposed when the chemicals move out of treated areas. Some persistent pesticides are of particular concern becaused they can accumulate in the bodies of animals. This process is referred to as bioaccumulation or bioconcentration. Many of the chlorinated hydrocarbons are both persistent and accumulative. These combined properties account for most of the environmental problems associated with their use.

Those pesticides which do accumulate in animal tissue may sometimes reach harmful levels in the organism which was initially exposed to the pesticide. More commonly, however, they remain below injurious levels in the initially exposed organism but become progressively more concentrated in the tissues of animals higher up in the food chain. A food chain simply describes the sequence whereby an animal feeds on a particular plant, animal or microorganism and is in turn eaten by another animal and so forth until we reach the animal at the top of the chain. At each succeeding level, an animal normally eats a number of individuals from a lower level of the food chain. An accumulative pesticide can become increasingly concentrated as it moves up the food chain. This process is referred to as biomagnification.

Biomagnification can begin when an animal eats a treated plant or perhaps more frequently when the chemical is absorbed from contaminated soil or water. Biomagnification is of particular significance in aquatic food chains. Man is not normally affected directly by this process simply because he is usually protected by residue tolerances for the food products he consumes. Fish and wildlife have no such protection.

Pollution of the environment can occur not only as result of pesticide applications but also as a result of spills and improper disposal of pesticides and pesticide containers.

Effects On Non-target Organisms

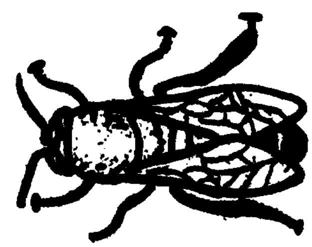
The effects of pesticides on non-target organisms may involve direct and immediate injury or may be due to long term consequences of environmental pollution. Pesticides may have an adverse effect on such non-target organisms as beneficial plants, bees and other beneficial insects, on livestock and on fish and wildlife.

Phytotoxicity

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

Herbicides may damage either the crop plants they are meant to protect or crops or other plants on adjacent land. Some herbicides which are persistent at the site of application may also injure succeeding crops. Injury to the crop to which the herbicide is applied occurs most frequently when the chemical has a narrow range of selectivity between the target weeds and the crop being treated. Injury to succeeding crops is particularly common when abnormally cold or dry weather inhibits degradation of the pesticide or when rates of application were unusually high. Damage to crops or other plants in adjacent areas is primarily due to drift or overspray, although it may sometimes be a consequence of surface runoff.

Effects On Bees



Research to resolve the problem of bee losses due to pesticides has been underway since 1881 when damage to bees by lead arsenate was first reported. A century later, there is still no solution to this problem. Modern agriculture is dependent on bees for crop pollination. Unfortunately, in the United States a large number of bees are killed each year by pesticides (principally insecticides). These losses have a significant economic impact on beekeepers and farmers alike. Some beekeepers are either being forced out of business entirely or are being forced to move to other locations. Yields from crops that require bees for pollination are frequently reduced.

Most pesticides, other than insecticides, are not hazardous to bees. However, the most preferred insecticides in agriculture are generally very toxic to bees. If an insecticide which is highly toxic comes in contact with foraging bees, the bees will, in all probability, be killed. Bee kills contained to a single field will most likely not have a large impact on the health of a colony. However, if within a relatively short period of time, similar kills occur in other fields visited by bees from the same colony, there can be serious damage to the overall health of the hive. If the hive itself is accidently sprayed or if it is located alongside a treated field, bee kills may be substantial.

A more serious type of poisoning may occur if pollen becomes contaminated with an insecticide. Bees will continue to forage for pollen in a routine fashion even after plants have been treated. The pollen will be carried back to the hive and be consumed by hive workers and often serious damage to the hive results.

The problem of bee losses due to pesticides is complex and no simple solution appears to be in sight. Each individual must strive for a balance between the use of pesticides and the protection of bees. Bee losses are frequently due to the inappropriate or careless application of pesticides, improper timing of application and improper disposal of unused materials. While it is unlikely that bee losses can be totally avoided, they can certainly be reduced with the safe and proper use of pesticides.

Growers and applicators should understand the foraging behavior of bees before applying pesticides. Bees will forage in fields where crops and/or weeds are in bloom. Application of pesticides to crops while they are in bloom should be avoided whenever possible. Every attempt should be made to eliminate weeds in bloom from areas to be sprayed. Applicators should also avoid spraying ditch banks, fence rows and roadsides where plants are in bloom and should keep in mind that drift onto these areas may also result in substantial bees losses. Pesticides should also be applied in early morning or in the evening when bees are not actively foraging.

Effects On Other Benefical Insects

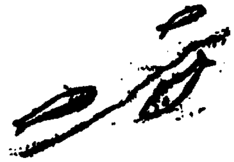
The other major groups of beneficial insects are the predators and parasites of agricultural pests. Despite the fact that they are valuable allies in keeping pest populations below damaging levels, man often overlooks them in his pest control programs. The loss of predators and parasites can have unexpected consequences. In their absence, the population of the target pest may rebound and may soon surpass pre-treatment levels simply because there are no natural enemies to keep it in check. This is referred to as resurgence of the pest population. In similar fashion, a pest which formerly caused little damage because its numbers were held in check by predators and parasites may suddenly begin causing significant damage, perhaps even greater than that caused by the primary pest.

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

Livestock Poisoning

The most important source of livestock poisoning by pesticides is contaminated feed or forage and contaminated drinking water. This contamination is often caused by simple carelessness. Direct applications to feed or forage crops may result in toxic residues if label directions for grazing or feeding intervals are ignored or if the pesticide is applied improperly. Drift and environmental pollution may also result in inadvertent contamination of feed and forage and contamination of drinking water. Poisoning can also result from improper application of chemicals used to control pests of livestock. Poisoning of livestock may cause illness or death of the animal or, at lower levels of exposure, may result in contaminated milk or meat.

Damage to Fish and Wildlife



Damage to fish and wildlife may occur either as a direct and immediate consequence of an improper pesticide application (example direct fish kills resulting from overspray or drift into an aquatic environment), as a result of contamination of wild plants used as a food source or as a result of indirect pollution of fish and wildlife habitats, principally through soil erosion, surface runoff and leaching. Except where direct kills are concerned, pesticides with longer persistence are a significantly greater hazard. Those which are both persistent and accumlative pose the greatest risks.

Pesticides may either be lethal to fish and wildlife or, at sublethal doses, may cause a variety of adverse effects including growth reduction, behavioral changes and decreased reproduction. It is believed that sublethal effects may be the most serious problem for wildlife. Many of the highly publicized effects of the chlorinated hydrcarbons on wildlife, notably on raptorial birds, have been related to reduced reproductive success.

Guidelines to Avoid Environmental Contamination

a. Use pesticides only when there is a definite need for pest control and there are no feasible alternatives.
b. Be sure that you have a problem that pesticides can correct. Apply them as a specific treatment not as a general remedy.
c. Use pesticides only on crops or animals that are being attacked by pests and in a fashion which will help avoid bee kills.
d. Do not apply more pesticide than is needed. A thorough application at the recommended rate is more effective, safer and economical than an excessive amount applied in a haphazard manner.
e. The need to dispose of pesticides can be reduced by mixing only the amount you need.
f. Do not drain surplus pesticides into sewage or septic tank systems.
g. Do not leave empty pesticide containers lying around. Empty containers still contain small amounts of toxic chemical that can seep into soil and water.
h. Follow all directions on the pesticide labeling.
i. Be aware of any and all consequences that may develop as a result of an application of a pesticide.

TERMS USED IN PEST CONTROL

Abscission: The separation of fruit, leaves or stems from a plant.

Absorption: The process by which a chemical is taken into plants, animals or minerals. Compare with adsorption.

Activator: A chemical added to a pesticide to increase its activity.

Adherence: Sticking to a surface.

Adjuvant: Inert ingredient added to a pesticide formulation to make it work better.

Adsorption: The process by which chemicals are held on the surface of a mineral or soil particle. Compare to absorption.

Adulterated: Any pesticide whose strength or purity falls below the quality stated on its label. Also, a food, feed or product that contains illegal pesticide residues.

Aerobic: Living in the presence of air. The opposite of anaerobic.

Aerosol: An extremely fine mist or fog consisting of solid or liquid particles suspended in air. Also, certain formulations used to produce a fine mist.

Agitation: The process of stirring or mixing in a sprayer.

Anaerobic: Living in the absence of air. The opposite of aerobic.

Antidote: A practical treatment for poisoning, including first aid.

Botanical Pesticide: A pesticide made from plants. Also called plant derived pesticides.

Carcinogenic: Can cause cancer.

Carrier: The inert liquid or solid material added to an active ingredient to prepare a pesticide formulation.

Chemosterilant: A chemical that can prevent reproduction.

Chlorinated Hydrocarbon: A synthetic organic pesticide that contains chlorine, carbon and hydrogen. Same as a organochlorine.

Chlorosis: The yellowing of a plant's green tissue.

Cholinesterase: A chemical catalyst (enzyme) found in animals that helps regulate the activity of nerve impulses.

Compatible: When two or more chemicals can be mixed without affecting each other's properties, they are said to be compatible.

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

Contaminate: To make impure or to pollute.

Corrosion: The process of wearing away by chemical means.

Deciduous Plants: Perennial plants that lose their leaves during the winter.

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

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

Dermal: Of the skin: through or by the skin.

Dermal Toxicity: Ability of a chemical to cause injury when absorbed through the skin.

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

Dilute: To make thinner by adding water, another liquid or solid.

Emulsifier: A chemical which aids in suspending one liquid in another.

Emulsion: A mixture in which one liquid is suspended as tiny drops in another liquid such as oil in water.

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

Immune: Not susceptible to a disease or poison.

Impermeable: Cannot be penetrated. Semi-permeable means that some substances can pass through and others cannot.

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

LD50: The dose of an active ingredient taken by mouth or absorbed by the skin which is expected to cause death in 50 percent of the test animals so treated. If a chemical has an LD50 of 10 milligrams per kilogram (mg/kg) it is more toxic than one having an LD50 of 100 mg/kg.

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

Miscible Liquids: Two or more liquids that can be mixed and will remain mixed under normal conditions.

Mutagenic: Can produce genetic change.

Necrosis: Localized death of living tissue such as the death of a certain area of a leaf.

Necrotic: Showing varying degrees of dead areas or spots.

Noxious Weed: A plant defined as being especially undesirable or troublesome.

Oral: Of the mouth: through or by the mouth.

Oral Toxicity: Ability of a pesticide to cause injury when taken by mouth.

Organic Compounds: Chemicals that contain carbon.

Organophosphate: A synthetic organic pesticide containing carbon, hydrogen, and phosphorus. Parathion and malathion are two examples.

Pathogen: Any micro-organism which can cause a disease. Most pathogens are parasites but there are a few exceptions.

Phytotoxic: Harmful to plants.

Pollutant: An agent or chemical that makes something impure or dirty.

PPM: Parts per million. A way to express the concentration of chemicals in foods, plants or animals. One part per million equals 1 pound in 500 tons.

Predator: An animal that destroys or eats other animals.

Propellant: Liquid in self pressurized pesticide products that forces the active ingredient from the container.

Soil Sterilant: A chemical that prevents the growth of all plants and animals in the soil. Soil sterilization may be temporary or permanent depending on the chemical used.

Soluble: Will dissolve in a liquid.

Solution: Mixture of one or more substances in another in which all ingredients are completely dissolved.

Solvent: A liquid which will dissolve a substance to form a solution.

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

Sticker: A material added to a pesticide to increase its adherence.

Surfactant: A chemical which increases the emulsifying, dispersing, spreading and wetting properties of a pesticide.

Susceptible: Capable of being diseased or being poisoned by moderate amounts of a pesticide.

Suspension: Finely divided solid particles mixed in a liquid.

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

Target Pest: The pest at which a particular pesticide or other control method is directed.

Tolerance: a) The ability of a living thing to withstand adverse conditions such as pest attacks, weather extremes or pesticides. b) The amount of pesticide that may safely remain in or on raw farm products at the time of sale.

Toxicant: A poisonous chemical.

Vector: A carrier such as an insect that transmits a pathogen.

Viscosity: A property of liquids that determines whether they flow readily. Viscosity usually increases when temperature decreases.

Volatile: Evaporates at ordinary temperatures when exposed to air.

Wetting Agent: A chemical which causes a liquid to contact surfaces more thoroughly.

COMPARATIVE WEIGHTS, MEASURES, ABBREVIATIONS AND DILUTION TABLES

FLUID MEASURE

1/6 fluid ounce	=	1 teaspoon (tsp.)		
1/2 fluid ounce	=	1 tablespoon (tbs.)	=	3 teaspoons
1 fluid ounce	=	2 tablespoons	=	1/8 cup
8 fluid ounces	=	1 cup	=	1/2 pint
16 fluid ounces	=	2 cups	=	1 pint
32 fluid ounces	=	4 cups	=	1 quart
128 fluid ounces	=	16 cups	=	1 gallon

AREA MEASURE

144 square inches = 1 square foot
9 square feet = 1 square yard
30 1/4 square yards = 1 square rod = 272 1/4 square feet
43,560 square feet = 1 acre
4,840 square yards = 1 acre
160 square rods = 1 acre
640 acres = 1 square mile

LINEAR MEASURE

1 inch = 2 1/2 centimeters = 25 1/2 millimeters
1 foot = 12 inches
1 yard = 3 feet
1 rod = 5 1/2 yards = 16 1/2 feet
1 mile = 320 rods = 1,760 yards = 5,280 feet

WEIGHTS

1 ounce = 28 1/3 grams
1 pound = 16 ounces = 453 1/2 grams
2 1/5 pounds = 1 kilogram = 1,000 grams
1 ton = 2,000 pounds = 907 kilograms

ABBREVIATIONS

P.S.I. = pounds per square inch
G.P.M. = gallons per minute
G.P.A. = gallons per acre
R.P.M. = revolutions per minute
M.P.H. = miles per hour
in. = inches
ft. = feet

MEASUREMENT CONVERSION FACTORS (APPROXIMATE)

Metric		X Conversion Factor	=	Customary
LENGTH				
mm	millimeters	0.04	inches	inches
cm	centimeters	0.4	inches	inches
m	meters	3.3	feet	feet
m	meters	1.1	yards	yards
km	kilometers	0.6	miles	miles
AREA				
cm^3	square centimeters	0.16	square inches	$in.^2$
m^2	square meters	1.2	square yards	$yds.^2$
km^2	square kilometers	0.4	square miles	$mi.^2$
ha	hectares (10,000 m^2)	2.5	acres	
VOLUME				
ml	millimeters	0.03	fluid ounces	fl. oz.
l	liters	2.1	pints	pint
l	liters	1.06	quarts	quart
l	liters	0.26	gallons	gallon
m^3	cubic meters	35.3	cubic feet	$ft.^3$
m^3	cubic meters	1.3	cubic yards	$yds.^3$

Customary		X Conversion Factor	=	Metric
LENGTH				
in.	inches	2.54	centimeters	cm
ft.	feet	30.5	centimeters	cm
yd.	yards	0.9	meters	m
mi.	miles	1.6	kilometers	km
AREA				
$in.^2$	square inches	6.5	square centimeters	cm^2
$ft.^2$	square feet	0.09	square meters	m^2
$yd.^2$	square yards	0.8	square meters	m^2
$mi.^2$	square miles	2.6	square kilometers	km^2
a	acre	0.4	hectares	ha
VOLUME				
tsp.	teaspoons	5.0	millimeters	ml
tbsp.	tablespoons	15.0	millimeters	ml
fl. oz.	fluid ounces	30.0	millimeters	ml
c.	cups	0.24	liters	l
pt.	pints	0.47	liters	l
qt.	quarts	0.95	liters	l
gal.	gallons	3.8	liters	l
$ft.^3$	cubic feet	0.03	cubic meters	m^3
$yds.^3$	cubic yards	0.76	cubic meters	m^3

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