APPLY PESTICIDES CORRECTLY
A GUIDE FOR COMMERCIAL APPLICATORS

AGRICULTURAL PEST CONTROL-- PLANT

U.S. ENVIRONMENTAL PROTECTION AGENCY
OFFICE OF PESTICIDE PROGRAMS
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CONTENTS

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PREFACE

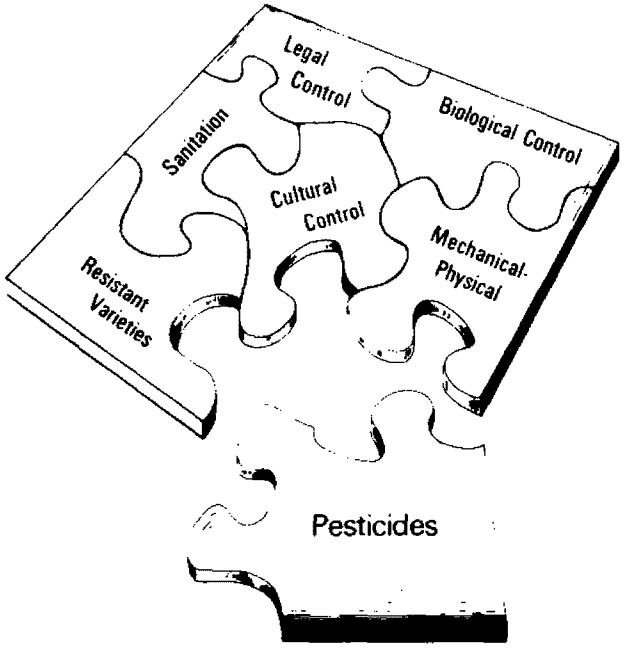
Federal regulations establish general and specific standards that you must meet before you can legally use certain pesticides. Your State will provide material which you may study to help you meet the *general* standards. This guide contains basic information to help you meet the *specific* standards for applicators who are engaged in agricultural plant pest control. Because the guide was prepared to cover the entire Nation, some information important to your State may not be included. The State agency in charge of your training can provide the other materials you should study.

INTRODUCTION

Pesticides are a valuable tool for profitably producing a high-yield, market-acceptable crop, but they should be used only when and where they are needed. Usually pesticides should be used only when pest numbers and/or the pest problem has reached the economic threshold and other pest management methods do not provide effective control. In some cases, preventive use is a necessary, cost-effective way to protect crops. Protectants should be used only when knowledge of the pest indicates it is necessary. You should be familiar with alternatives to the use of pesticides and inform your customers about them. Be sure they know the possible consequences of both pesticide use and the use of alternative control methods.

Sometimes a producer asks you to apply a specific pesticide on a crop. At other times you are asked to both diagnose a pest problem and to provide control. Accurate detection, identification, or diagnosis is a science. Experience is important. This manual is not intended to make anyone an expert in identifying pests on crops or in selecting the proper control technique. However, you should be able to identify the more common pests that attack agricultural crops. When you find a pest or pest problem you cannot identify, ask an expert to help you.

Integrated Control



This manual discusses some of the general production practices that may increase or lessen pesticide problems. You will be a better applicator if you understand these basic principles.

You as an applicator should:

- understand crop production and cropping practices,
- be able to identify common pests and signs and/or symptoms of the damage they cause,
- have basic knowledge of the chemical characteristics and the mode of action of pesticides,
- understand application techniques and equipment use,
- recognize pesticides' potential for injury to people, pets, livestock, and the environment, and
- know and follow the safety practices essential for protecting yourself and your employees, the producer and his employees, the consumer, and the environment.

MAJOR CROPS

Feed Grains and Small Grains

Crop Characteristics

These widely grown crops are summer or winter annual grasses. In the past, seedbed preparation usually included complete removal or incorporation of the previous year's crop residue. This practice contributes to wind and water erosion of soil particles and the attached pesticides. No-till seeding is becoming more common. It minimizes erosion and may simplify weed control, but its impact on disease, rodent, and insect control is not known.

These crops have a relatively low unit value. As a result, per acre pest control costs must be kept low. Resistance to several common diseases and insect pests is good in some of the more popular crop varieties. Certain cultural control practices may reduce the need for pesticides. These include:

- no-till seeding,
- moldboard plowing,
- cultivation,
- crop rotation,
- planting date and harvest date timing, and
- special harvest and storage methods.

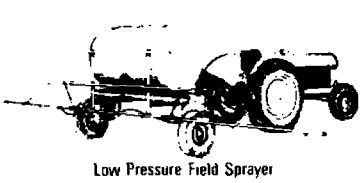
These methods may be used alone or in combination.

Many producers use pesticides preventively to control some soil-infesting insects such as wireworms, plant disease agents such as nematodes, and weeds such as pigweed and foxtail.

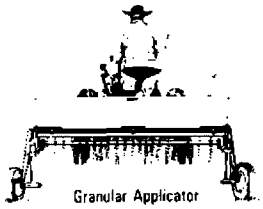
Machines are widely used in the production and harvest of these crops. This lessens worker exposure to pesticide residues. However, these crops are used as food or feed, so be sure to inform your customer of the limitations on the time between pesticide application and harvest, slaughter, or grazing.

Equipment

Many types of low-pressure field sprayers are used, ranging in capacity from 50 gallons to more than 1,000 gallons. They can do many highly specialized jobs.



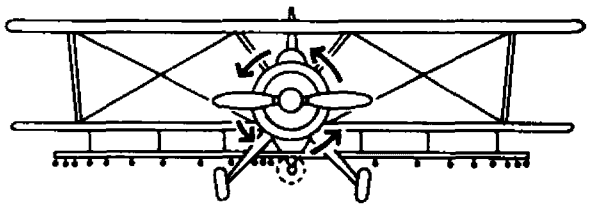
Low Pressure Field Sprayer



Granular Applicator

Dry formulation application equipment also comes in a wide variety of sizes and capabilities.

Aircraft can be specially adapted for the different applications of pesticides to these crops.



Hay and Pasture

Crop Characteristics

These widely grown crops include:

- intensively cultivated alfalfa, clover, and grasses introduced in most parts of the country, and
- native grasses and broadleaved plants grown with a minimum of cultivation.

Resistant varieties, harvest timing, and other nonchemical control practices such as burning are especially useful in pest control in hay crops. Hay producers often use fall seeding, or plant with spring-seeded small grains as a nurse crop to control weeds. Without insect- and disease-resistance, alfalfa could not be grown over much of its present range in the United States.

Since all hay and pasture crops are used for livestock feed, it is essential to obey time limitations between pesticide application and grazing or harvest. Especially restrictive residue tolerances apply to milk and dairy products.

Equipment

Pesticides are usually applied to hay and pasture crops with low-pressure boom sprayers or aircraft equipped to apply both liquid and dry formulations.

Fruits and Nuts

Crop Characteristics

Small fruits include such crops as grapes, brambles, blueberries, strawberries, and cranberries. Tree fruits include such crops as apples, peaches, pears, citrus, cherries, and plums. Nuts include such crops as walnuts, almonds, and pecans.

Highly sophisticated pest control practices are used on fruits grown for human consumption. In some situations, the crops are closely monitored for pests. If pests are found, pesticides may be recommended. The surface appearance of fruits grown for fresh market has long been critical to the producer. To produce blemish-free fruit, the producer sometimes must use pesticides preventively on a schedule modified only to adapt for variable weather.

Many fruit crops must be harvested by hand labor. Hand labor is also required to prune fruit trees and to thin some crops selectively during the growing season. Pesticide labels specify time intervals between pesticide application and reentry or harvest. These directions are critical and must be obeyed. The law requires applicators to inform their customers and employees of these intervals.

Two or more pesticides often are applied in combination. Pesticides may also be combined with fer-

tilizers. The applicator must pay strict attention to their physical and chemical compatibility. The labeling on chemical products sometimes identifies problems of incompatibility. Follow label instructions exactly.

Many of these crops are perennial and may remain in place for decades. Pesticides may persist on orchard or vineyard soil from repeated use. Local experts are aware of potential residue problems. They can help you.

Equipment

Equipment most often used on these crops includes:

- air blast sprayers with fixed or movable heads,
- high-pressure sprayers with fixed or movable booms,
- dusters,
- hand-held booms, and
- aircraft.

High Pressure Field Sprayer

Air Blast Sprayer or Mist Blower

Vegetables

Crop Characteristics

In general, these are intensively cultivated annual plants, the fruits, stems, leaves, or roots of which are used as human or livestock food. Vegetables, like tree fruits, are expected by the consumer to have a blemish-free appearance. Since the edible portions of most of these crops are produced under an intensive schedule of pesticide application, worker reentry and pre-harvest intervals are critical to protect field workers, harvesters, and consumers.

Resistant varieties and cultural control methods, including selective planting and harvesting dates and destruction or removal of cultivated crop residue, are an important part of pest control on vegetables.

Equipment

Pesticide application equipment most often used on vegetables includes:

- fixed- and movable-head air blast sprayers,
- high- and low-pressure boom sprayers,
- dusters,
- granular applicators, and
- aircraft.

Specialty Crops

Crop Characteristics

Specialty crops include cotton, soybeans, tobacco, sugar beets, sugar cane, and peanuts. Most are row seeded and managed much the same as the feed grains and small grains. Some of these crops, such as cotton and soybeans, require extensive use of pesticides for successful production. Other specialty crops, such as sugar beets and sugar cane, can be produced almost without the use of pesticides.

Equipment

Pesticide application equipment most often used on these crops is low-pressure boom sprayers and aircraft-mounted sprayers.

PESTS

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

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

Pests can be put into five main groups:

- insects (plus mites, ticks, and spiders),
- plant disease agents,
- snails and slugs,
- weeds, and
- vertebrates.

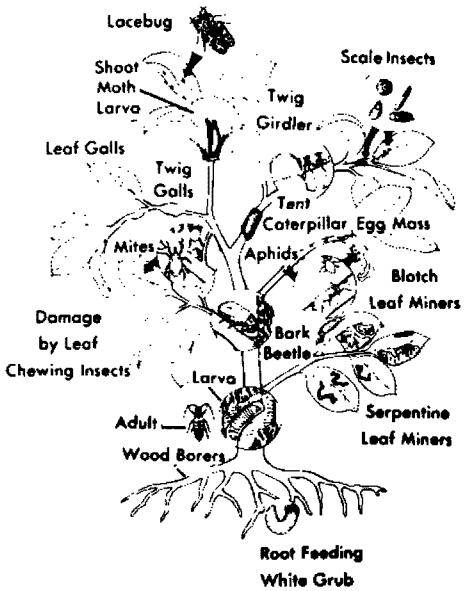
Most applicators know most of the pests they see on the job. But sometimes unfamiliar pests may appear. You can get identification aids, publications, and pictures to help find out what they are. But the best thing to do is to contact local experts. Ask the Cooperative Extension Service or a competent consultant to help you.

Insects and Mites

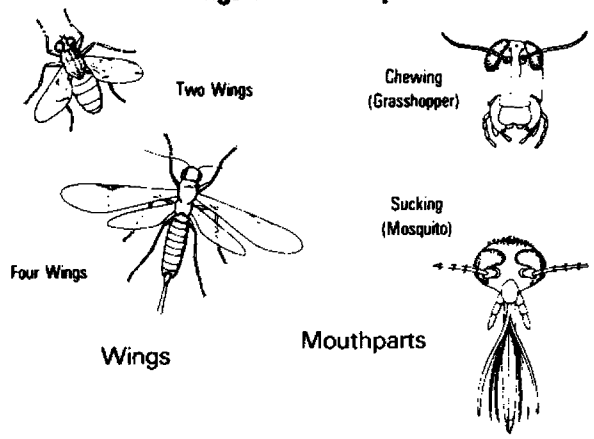
The large number of insects, mites, and related animals can be divided into three categories according to their importance to man:

- **species which are of only minor importance**—About 99 percent of all species are in this category. They simply "take up space" and supply food for birds, fish, mammals, reptiles, amphibians, and other insects. Some have esthetic value.
- **beneficial insects and mites**—In this small but important group are the predators and parasites that feed on destructive insects, mites, and weeds. Examples are lady beetles, some bugs, ground beetles, tachinid flies, many tiny parasitic wasps, and predaceous mites. Also in this category are the pollinating insects, such as bumblebees and honeybees, some moths, butterflies, and beetles. Without pollinators, many fruits, vegetables, and forage crops could not be produced.
- **destructive insects and mites**—Although this is the category which usually comes to mind when insects are mentioned, it includes the smallest number of species. In this category are certain species of thrips, grasshoppers, true bugs, aphids, leafhoppers, scales, whiteflies, moths, beetles, flies, sawflies, and mites that feed upon food and fiber crops.

Insect Damage



Wings and Mouthparts

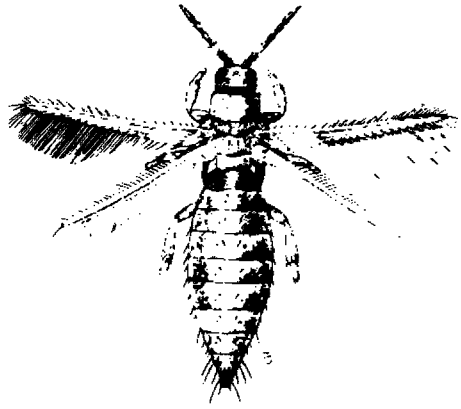


Thrips

Thrips are thin, tiny insects with four narrow fringed wings in the adult stage. During their life cycle they change gradually in size and slightly in form from egg through several wingless nymphal stages to winged adults. Several generations are produced each year. Both nymphs and adults have tube-like mouthparts and feed on plants by rasping the surface tissue of tender buds, flowers, fruits, and leaves, then sucking the plant juices (sap).

Injury to plants is characterized by discolored and distorted flowers and buds or grey speckled areas on fruit and foliage. Thrips may attack every type of agricultural crop. Common species are:

- bean thrips on legumes,
- citrus thrips,
- flower thrips on grasses, vegetables, and fruits,
- onion thrips on onion and other vegetables, and
- tobacco thrips.



GLADIOLUS THRIPS

Grasshoppers and Crickets

Grasshoppers and crickets are large-bodied insects with hind legs adapted for jumping. During their life cycle they change gradually in size and slightly in form from egg through several wingless nymphal stages to winged or wingless adults. Usually there is only one generation produced each year. The eggs overwinter in the soil. Both nymphs and adults have toothed (chewing) mouthparts which they use to cut small sections from leaves and stems of plants.

Injury is characterized by ragged holes in foliage and stems. In large numbers, grasshoppers and crickets may consume all of a plant or plants in an area. Grasshoppers and crickets may attack every type of agricultural crop. Common species include Mormon cricket, mole cricket, field cricket, migratory grasshopper, and two-striped grasshopper.

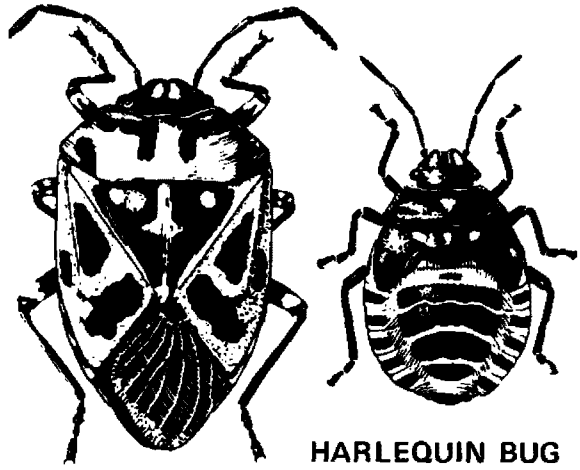
True Bugs

Pest species of true bugs in the adult form have two pairs of wings. The first pair is leathery at the base and nearly transparent at the tip. At rest, the wings lie flat across the thorax and abdomen with the transparent tips overlapping. During their life cycle true bugs change gradually in size and slightly in form from egg through several wingless nymphal stages to winged adults. One to several generations are produced each year. Both nymphs and adults have tubelike (piercing-sucking) mouthparts and feed on plants by puncturing seeds, stems, foliage, flowers, or fruit and sucking the sap. Some true bugs may inject a toxin into the plant which causes further damage.

Injury to plants is characterized by mottled grey spots on foliage, deformed buds or fruit (catfacing), loss of vitality, wilting, and—in severe infestations—death. Some plant disease agents are carried by these insects. True bugs may attack many kinds of fruit, vegetable and grain crops.

Common species include:

- chinch bug—corn and grain crops,
- harlequin bug—crucifers,
- stinkbug—vegetable crops,
- squash bug—vine crops, and
- tarnished plant bug—vegetables and fruits.

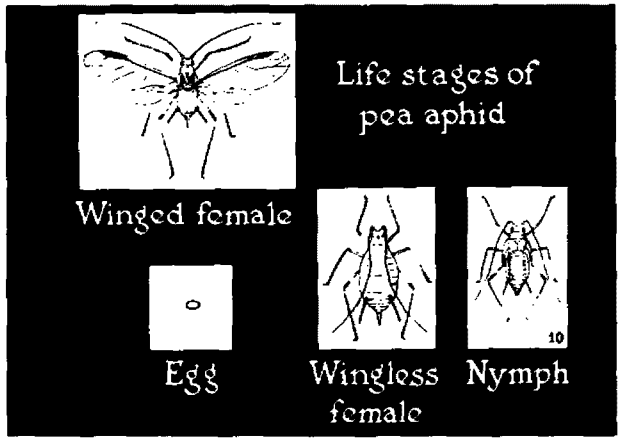


HARLEQUIN BUG
ADULT AND NYMPH

Aphids and Psyllids

Aphids and psyllids, called plant lice and jumping plant lice, are small, soft-bodied insects usually less than ¼ inch long. In the adult form they usually have transparent wings which are held vertically over the body when at rest. During their life cycle they change gradually in size and slightly in form from egg through several wingless nymphal stages to winged and wingless adult stages. Many generations are produced each year. Both nymphs and adults have tubelike mouthparts and feed on plants by puncturing tender plant parts and sucking the sap.

Injury to the plant is characterized by loss of plant vigor, stunted and deformed buds and flowers, or curled and puckered foliage. Plant lice and jumping plant lice secrete honeydew which attracts ants and upon which unsightly sooty mold grows. Aphids also transmit some viral, bacterial, and other plant disease agents.



Common aphid species include:

- grape phylloxera,
- the greenbug—grains,
- green peach aphid—tobacco, peaches, potatoes, spinach,
- melon aphid—melons, cotton, fruits, vegetables,
- potato aphid—potato, tomato, and
- apple aphids.

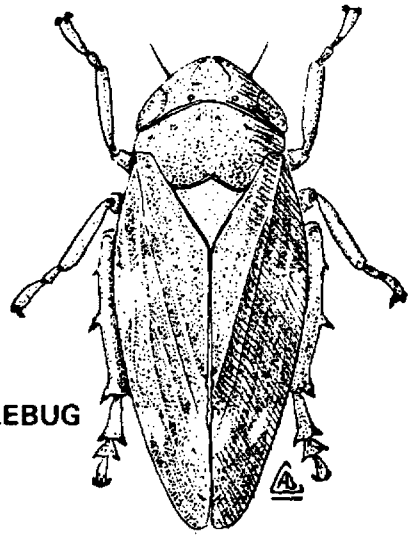
Common psyllids are:

- potato psyllid—potato and tomato, and
- pear psyllid.

Leafhoppers, Spittlebugs (Froghoppers) and Treehoppers

Leafhoppers, spittlebugs and treehoppers are small (usually not over ½ inch long), soft-bodied insects with hind legs adapted for jumping. The adults have two pairs of transparent wings held in a rooflike position when at rest. During the life cycle they change gradually in size and slightly in form from egg through several wingless nymphal stages to winged adults. Many generations are produced each year. Both nymphs and adults have tubelike mouthparts and feed on plants by piercing leaves and stems and sucking the sap.

Injury to the plant is characterized by mottled, discolored, and curled leaves, and stunted or wilted stems. Spittlebug nymphs are easily identified by the foamy spittle mass which surrounds and protects them during feeding. All these hoppers may transmit plant disease agents, especially those agents causing yellows, stunt, and curlytop.



SPITTLEBUG

Some leafhoppers secrete honeydew, which attracts ants and supports the growth of unsightly sooty mold. Other leafhoppers inject a toxin into the plant during feeding, causing a browning of leaves called "hopper burn." Treehoppers damage plants by slitting the bark or stem to deposit their eggs.

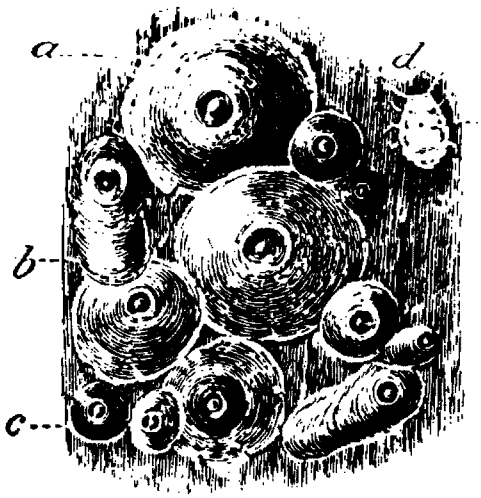
Common species include:

- buffalo treehopper—tree fruits,
- alfalfa hopper,
- meadow spittlebug—strawberries, legumes, forage crops,
- aster leafhopper—lettuce, celery, other vegetables, grains,
- potato leafhopper—potato, legumes, apples.

Scales and Mealybugs

Scales and mealybugs are small, oval insects which resemble reptile scales or tiny bits of wax or wool. They may be mistaken for parts of the plant itself. Mealybugs are soft-bodied scales covered with white powder and often with cottony fibers. Scales may be soft-bodied or armored with a crusty shell. Adult females are wingless and usually stationary, but adult males resemble tiny flies with a single pair of wings.

During the life cycle they change gradually in size and slightly in form from egg through several wingless nymphal stages and a pupalike stage to adults. Many generations are produced each year. Adult males do not have mouthparts and do not feed. Nymphs and adult females have very long, slender, tubelike mouthparts. They feed on plants by sucking sap from plant stems, leaves, and branches.



San Jose Scale: (A) Adult Female Scale; (B) Male Scale; (C) Young Scales; (D) Nymph (Crawler)

Injury is characterized by stunted, yellowed, wilted, and often deformed growth. Scales and mealybugs also transmit some plant disease agents and secrete large amounts of honeydew, which attracts ants and supports unsightly sooty mold. Large quantities of sooty mold on crops usually indicates an aphid or scale infestation. Mealybugs and scales may attack many kinds of fruit, vegetable, and especially greenhouse crops.

Common species include:

- citrus mealybug—citrus fruits, greenhouse crops,
- Mexican mealybug—cotton, greenhouse crops,
- red scales—citrus fruits, other tree fruits,
- San Jose scale—tree fruits,
- brown soft scale—tree fruits, ornamentals,
- black scale—citrus.

MEALYBUGS

Whiteflies

Whiteflies are tiny, soft-bodied insects covered with white, waxy powder. The adults have two pairs of broad wings and resemble tiny white moths. During the life cycle they change gradually in size and form from egg through several wingless, scalelike nymphal stages and a pupalike stage to winged adults. Several generations are produced each year.

Both nymphs and adults have long, slender tubelike mouthparts and feed on plants by sucking plant juices. They also secrete honeydew. Whiteflies attack greenhouse crops in the North and a wide variety of outdoor agricultural crops in the South.

Common species include:

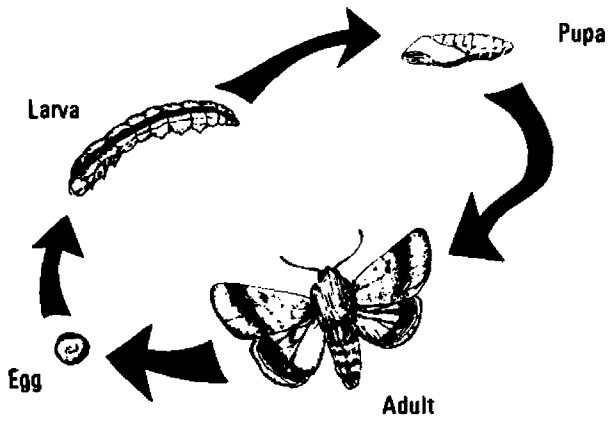
- citrus whitefly,
- greenhouse whitefly.

Moths and Butterflies

Moth and butterfly adults have a dense covering of tiny scales and hairs on their wings and bodies which gives the body a soft, fuzzy appearance. The adults have two pairs of fairly large wings which are usually brightly colored in butterfly species and dull, neutral-colored in moth species.

During their life cycle they change completely in size and form from egg to wingless wormlike larva to immobile pupa to winged adult. One to several generations are produced each year. Adults have long tubelike mouthparts and feed on plants by sucking or siphoning plant nectar. They do not harm plants; however, their presence around crops or in pheromone or light traps may indicate potential pest problems. The adults lay eggs that hatch into potentially harmful larvae.

Four Stage Life Cycle



The larvae, called caterpillars, are long, fleshy, and soft-bodied with three or more pairs of legs. They have well-developed, toothed jaws and feed on plants by cutting and tearing leaves, stems, and other plant parts. Different kinds of caterpillars feed on all parts of herbaceous and woody plants including roots, stems, foliage, buds, flowers, fruits, and seed. Injury to plants is characterized by tears, tunnels, and ragged holes in the affected plant part.

Budworms

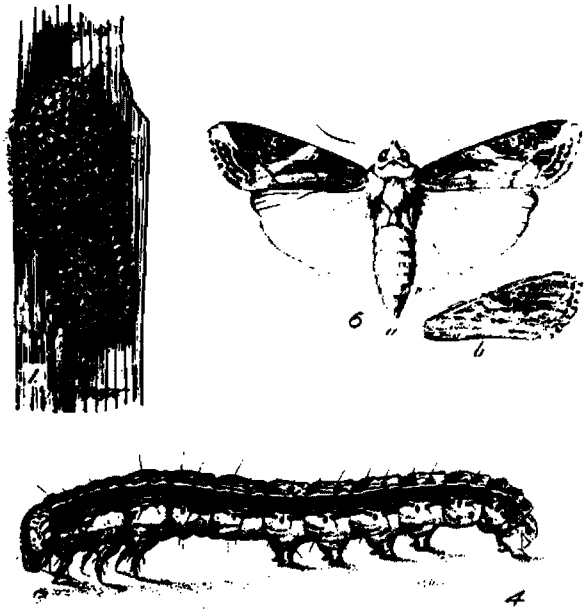
Budworms are medium-sized caterpillars that feed in or on opening buds. Common species include:

- pecan budworm,
- tobacco budworm—tobacco, cotton.

Several other destructive caterpillars, such as the corn earworm, fall armyworm, and European corn borer, may feed on or in developing buds. Although these are not true budworms, the injury they cause is often called "budworm injury."

Armyworms

Armyworms occur in large numbers, and may destroy every plant in their path. They will eat any part of a herbaceous plant, especially stems, leaves, and fruits. Common species are the fall armyworm and true armyworm, both of which attack grasses and cereal grains.



ARMYWORM: (1) EGG MASS; (4) LARVA; (6) ADULT

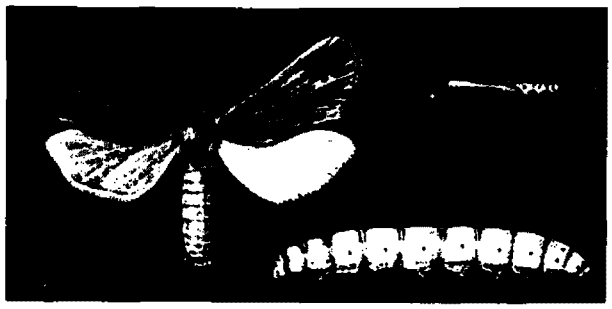
Cutworms

Cutworms usually feed near the soil surface by cutting through succulent stems of young plants. Some cutworms can climb up stems and trunks to feed on buds, leaves, and fruit and are called climbing cutworms. Different species of cutworms may attack many kinds of agricultural crops. Black cutworm is a common surface-feeding caterpillar on many vegetables and grain crops. Variegated cutworm will feed on the soil surface and also act as a climbing cutworm attacking herbaceous and woody tissues on fruits and vegetables.

Borers

Borers are caterpillars which bore into and feed on stems, woody tissues, and roots. Some other insect larvae are also borers. They may attack young fruit and nut trees and row crops. Common species include:

- common stalk borer—corn, potato, tomato, other stem plants,
- European corn borer—corn, beans, peppers, potatoes,
- peach tree borer—stone fruits,
- potato tuberworm—Irish potatoes,
- citrus borer.



DURRA STALK BORER: ADULT (LEFT); PUPA (TOP RIGHT); LARVA (BOTTOM RIGHT)

Fruitworms

Fruitworms and some other caterpillars bore into and feed on the fruits of plants. The caterpillar of one moth species may be called the corn earworm, tomato fruitworm, or cotton bollworm, depending on where it is feeding. These caterpillars also bore in and feed on beans, cabbage, peanuts, grasses, grains, and other crop plants. Other common species include:

- oriental fruit moth—tree fruits,
- codling moth—tree fruits,
- green fruitworm—tree fruits,
- pickleworm—crucifers,
- tomato pinworm—tomato, potato.

Foliage Feeders

Foliage feeders are by far the largest group of caterpillars. They may feed on the leaves of every type of agricultural crop.

Webworms and Tent Caterpillars are caterpillars that build a nest or "tent" of silk. Webworms feed entirely within the web, which is built around the foliage and is extended as the enclosed leaves are consumed. Tent caterpillars build tentlike nests in the crotch of a tree and leave the nest to feed on the foliage. Common species include:

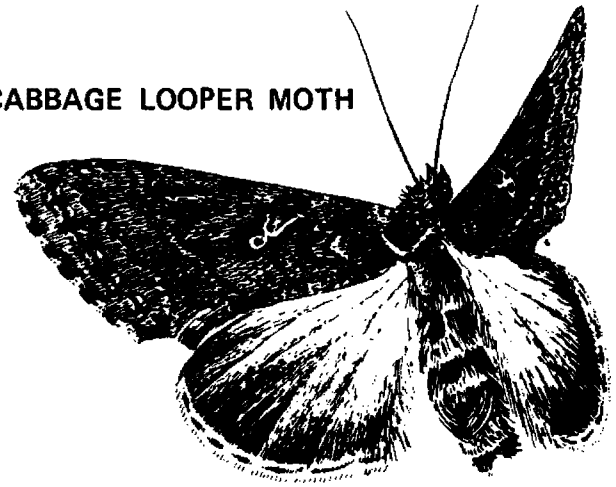
- eastern tent caterpillar—apples,
- fall webworm—tree fruits, nuts,
- garden webworm—grass, cereal grains, vegetables.

Hornworms are very large, foliage-feeding caterpillars with a hornlike projection at the end of the body. Two common species are tobacco and tomato hornworms, both of which attack tobacco, tomatoes, potatoes, and peppers.

Loopers, Cankerworms, and Spanworms are foliage-feeding caterpillars which move by drawing the abdomen to thorax to form a loop and then extending again. They often drop down and dangle on a long silken thread when disturbed. Common species include:

- fall and spring cankerworms—tree fruits, nuts,
- cabbage looper—cole crops, lettuce, other vegetables,
- currant spanworm—currants, gooseberries.

CABBAGE LOOPER MOTH

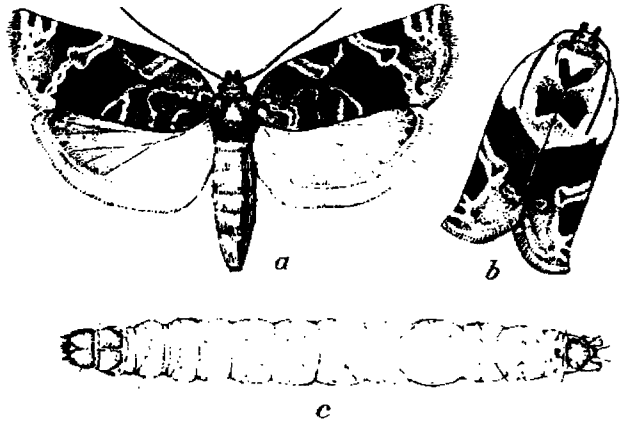


Other Foliage-Feeding Caterpillars include such species as:

- redhumped caterpillar—fruits, nuts,
- imported cabbageworm—cole crops,
- parsley worm—many vegetables.

In addition, there are several pest species with common names that describe how they attack and injure leaves. For example:

- *leaf crumplers* crumple new leaves together with a silken thread and feed on new leaves and buds of some fruit crops,
- *leaffolders* feed inside folded leaves of some small fruit crops,
- *leafminers* mine in and feed between the surfaces of leaves of many fruit and vegetable crops,



RED–BANDED LEAF ROLLER

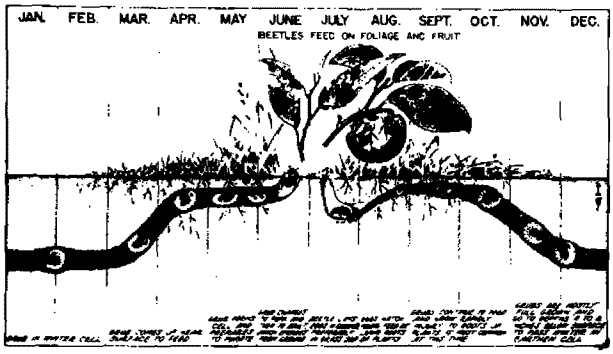
- *leafrollers* feed within the rolled up leaves of many fruit and vegetable crops,
- *leaf skeletonizers* skeletonize leaves of some fruits, vegetables, and specialty crops by eating everything but the veins and outer layer.
- *leaftiers* tie together and feed on the leaves of some small fruit crops.

Beetles

Beetles are the largest group of insects. They make up about 40 percent of known insect species. Adults are easily identified by the pair of hardened, opaque wings that meet in a straight line down the thorax and abdomen and the folded second pair of transparent wings.

During their life cycle, beetles change completely in size and form from egg to wingless, wormlike larva to immobile pupa to winged adult. One generation may be produced every 2 to 5 years or several generations may be produced each year. Both the larvae, some of which are called grubs, and the adults have distinct, hard, capsulelike heads with toothed jaws.

They feed on plants by biting and tearing the food. Many adult beetles feed on plant foliage or fleshy stems. Larvae may feed on roots, stems, foliage, buds, seeds, fruits, or woody tissue. Injury to the plant is characterized by tears and ragged holes in the affected plant part. In some species both the adult and the larva are pests. In other species only one stage causes damage.

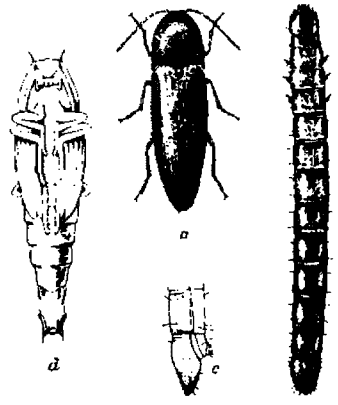


LIFE CYCLE OF THE JAPANESE BEETLE

Rootfeeding Larvae

These include wireworms, rootworms, and other beetles. The root-eating larvae feed on and burrow in roots and underground stems. Wireworms also attack seeds.

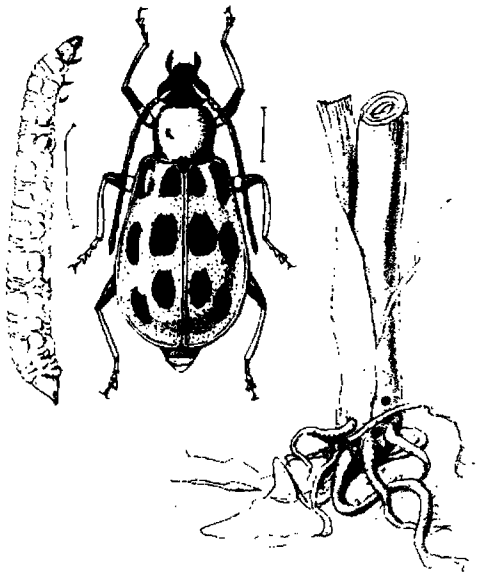
Wireworms are shiny, slender, hard-bodied, wirelike, yellow to dark brown larvae. They may be found at all times of the year in almost any soil. The adults, which are not important pests, are called click beetles because they right themselves with a sharp click if held or disturbed. Many species are pests. They may attack all agricultural crops, especially corn, grasses, tobacco, cotton, and root vegetable crops.



COMMON WIREWORM: (A) ADULT; (B) LARVA; (C) LAST SEGMENTS OF LARVA; (D) PUPA

Rootworms are small, curved, white, soft-bodied, wormlike grubs. The adult beetles are leaf-feeders and may attack the foliage of entirely different plant species than the crops injured by the grubs. For example, the clover rootworm, which feeds on pasture, hay, and grain crops, becomes the grape colapsis beetle, which feeds on small fruit and vegetable crops. The southern corn rootworm, which feeds on corn and beans, becomes the spotted cucumber beetle, which feeds on legumes and cucurbits. Other common species include:

- northern corn rootworm,
- strawberry rootworm—small fruits, tree fruits, nuts.



SOUTHERN CORN ROOTWORM LARVA (LEFT); ADULT (CENTER); DAMAGE CAUSED (RIGHT)

Other beetles with root-feeding larvae also include species in which the adults feed on different hosts than the grubs do. Japanese beetle adults feed on all fruits and on corn and soybean foliage, but the grubs feed on grass roots. May and June beetle adults feed on foliage of ornamental trees and shrubs, but the grubs feed on roots of hay, pasture, grain, and vegetable crops. The striped cucumber beetle adults feed on foliage of cucurbits, legumes, and corn, but the larvae feed only on cucurbit roots.

Stem-Eating Larvae or Borers

Stem-eating larvae tunnel in and feed on stems and woody tissues. The adult beetles often cause

damage by carving holes in stems and bark to insert eggs, as well as by eating foliage. Borers are particularly destructive to newly set or weakened fruit and nut trees and young herbaceous crops. Common species are:

- potato stalk borer—potatoes, tomatoes,
- cane borers—small fruits,
- shot hole borer—fruits, nuts,
- round headed and flat headed borers—tree fruits, nuts.

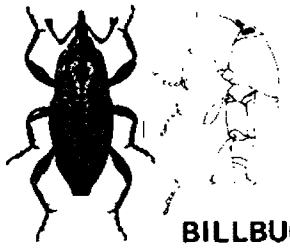
Fruit- and Foliage-Eating Larvae

This group includes snout beetles and other beetles. In many species of beetles, both larvae and adults feed on foliage and fruit.

Snout Beetles (Curculios, Billbugs, and Weevils)—The head of the adult snout beetle is shaped in a long, curved snout with toothed mouthparts at the tip. The larvae are white, thick, soft-bodied, legless grubs. The grubs commonly feed within the plant; the adults feed from the outside. The snout of the adult beetle is used to cut a hole in stems, nuts, buds, fruits, or vegetables into which the eggs are deposited. The hatching grubs eat and bore their way further into or along the stem or fruit.

Snout beetles which feed on hay, pasture, grain, and soybean crops are commonly called billbugs. Common species are:

- southern corn billbug—corn, rice, peanuts,
- maize billbug.



BILLBUG

Snout beetles which feed on fruits and nuts may be called curculios. Common species include:

- apple curculios—tree fruits,
- plum curculios—stone fruits, apples.

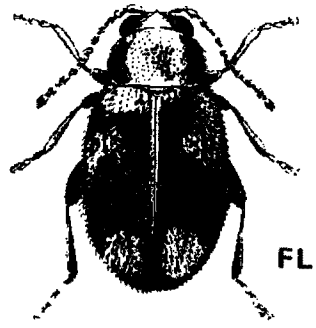
Snout beetles which attack vegetables and specialty and ornamental crops are often called weevils. Common species are:

- alfalfa weevil,
- cotton boll weevil,
- bean weevil—bean seeds,
- pea weevil—pea seeds.

ALFALFA WEEVIL

Other Fruit- and Foliage-Feeding Larvae are not snout beetles. The larvae of these beetles usually feed on the outside of the plant along with the adult beetles. The adults usually deposit the eggs on the leaf or stem surface rather than into the plant. Common species include:

- flea beetles—vegetables,
- Colorado potato beetle—potatoes, tomatoes,
- Mexican bean beetle.



FLEA BEETLE

Non-Plant-Eating Larvae

The larvae of some pest beetles do not eat plants but prey on insects, mites, and other animals. The adults are called blister beetles because they contain a chemical which may blister human skin. The adult blister beetles chew on foliage and fruits and may be very destructive to agricultural crops. The larvae of blister beetles are parasitic on grasshopper eggs. Numerous species feed on vegetables, flowers, young trees, and vines.

MARGINED BLISTER BEETLE

Flies, Gnats, and Midges

Flies, gnats, and midges are the major types of insects with only one pair of wings. During their life cycle they change completely from egg to wingless, wormlike larva to immobile pupa to winged adult. The pupal stage of most pest flies is buried in the soil and adults emerge from the soil to feed. Several generations are produced each year.

Adults have piercing-sucking or sponging mouthparts. Many adults feed upon nectar and pollen of flowers. Others feed upon liquid organic matter from decomposing plant or animal bodies. Others dissolve solid substances in their saliva and sponge up the solution. A number of adults suck juices from other insects and animals, including man.

HESSIAN FLY

The larvae, called maggots, are usually soft, thick, white, and legless with a head which is not well defined. Maggots have well-developed, parallel hooked jaws. They feed on plants by burrowing in and feeding on roots, stems, and fruit. The maggots are usually the most destructive stage.

Injury to plants is characterized by wormy or decayed seeds, stems, fruits, and roots; wilted foliage; stunted growth; or death of the plant. These insects may also transmit some plant disease agents, especially those causing soft rot.

Common species include:

- apple, cabbage, pepper, and onion maggots,
- seed corn maggot—vegetable seeds,
- melon fly—cucurbits,
- Hessian fly—wheat,
- sorghum midge—grasses, cereal grains,
- fruit flies.

Sawflies

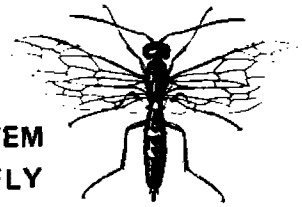
Sawflies belong to the group of insects that includes bees, wasps, and ants. Sawfly larvae resemble caterpillars. The adults have two pair of transparent wings hooked together. During their life cycle they change completely from egg to wingless wormlike larva to immobile pupa to winged adult. One to a few generations are produced each year.

Larvae and adults have toothed jaws and feed on plants by tearing soft stems and foliage. The adults damage plants mainly by sawing into leaves to deposit eggs. The larvae are the most destructive stage. They bore into and feed on stems and leaves, often by burrowing between the surfaces of a leaf as leafminers do.

Injury to plants is characterized by slits in leaves; lumpy, wilted foliage; and stunted growth.

Common species include:

- stem sawflies—grasses, cereal grains,
- cherry fruit sawfly—tree fruits,
- imported currantworm—currants, gooseberries.



WESTERN GRASS STEM SAWFLY

Mites

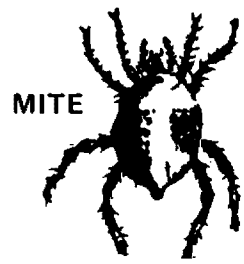
Mites are minute, soft-bodied, wingless pests which closely resemble insects but have eight legs. Nymphs and adults have sucking mouthparts. They usually are so tiny that they are discovered only after the damage to the plant appears. The life cycle includes both larval and nymphal stages. The larvae have three pairs of legs; the nymphs and adults have four pairs. Several generations are produced each year.

Foliage, buds, stems, and fruit of infested plants may become red, bronze, rust, yellow, white, or brown or may wither and fall off. Spider mites spin light, delicate webs over buds and between leaves where mites are feeding. Mites attack almost all types of agricultural crops.

Common species include:

- spider mites—fruit trees, citrus, small fruits, legumes, greenhouse crops,

- clover mite—grasses, cereal grains,
- red mites—tree fruits, citrus, nuts.



Plant Disease Agents

Both living organisms and nonliving agents often cause diseases or other undesirable effects on plants.

- Living organisms include fungi, bacteria, viruses and mycoplasmas, nematodes, and parasitic seed plants.
- Nonliving agents include unbalanced soil fertility, toxic chemicals, air pollution, frost, drought, sunburn, wind, and hail.

Disorders caused by nonliving agents often resemble the symptoms of injury caused by living organisms. For example, certain types of chemical injury can look like some of the leafspots caused by fungi or bacteria.

Symptoms and signs are the keys to identifying plant disease. A *symptom* of a disease is the reaction of the host plant to the living organism or to the nonliving agent. Symptoms include such things as spots on the leaves, wilting, and galls on the roots. A *sign* is physical evidence of the presence of a disease agent. Signs include, for example, the visible growth of fungi (mold) or fungal spores, or bacterial ooze issuing from a wound.

Some living organisms cause entirely different symptoms on different kinds of plants. Cedar apple rust on cedar appears as gall-like swellings on twigs, but on apple it appears as small, rustlike spots. Diseases caused by nematodes may have no visible above-ground symptoms if soil moisture is adequate. Root knot nematode injury on peanuts is an example. A plant may be infected by two or more disease agents at the same time.

Fungi

Fungi are plants that lack chlorophyll and cannot make their own food. They get food by living on other organisms. Most fungi reproduce by spores, which function about the same way seeds do. Locating and recognizing the spores may be a key to identifying a fungus as the cause of a plant disease. Fungi may attack crops both above and below the soil surface. Fungal disease agents may be spread from plant to plant and crop to crop by such things as wind, rain, insects, birds, machinery, soil, and contaminated seed stock.

Leaf Diseases

Although the fungi causing these diseases occur primarily on leaves, some may also occur on stems, roots, or fruits. Fungi that cause leaf diseases produce several types of symptoms. Other plant disease agents may produce similar symptoms.

Leaf Spots—Leaf spots (other names—anthracnose, scab, leaf blotch, shot hole) are usually definite spots of varying sizes, shapes, and colors. Each spot usually has a distinct margin, sometimes surrounded by a yellow halo. Usually there is a fungal growth such as tiny, black, pimplelike structures or a moldy growth. It is often necessary to use a hand lens to see these signs. If the spots are numerous or close together, affected areas may join together to form irregular areas, often called "blotches". Leaf spots are common on fruits, vegetables, and some hay and pasture crops.

The common names of leaf spot diseases may be general (peanut leaf spot), descriptive (zonate leaf spot), or named after the fungus (Septoria leaf spot).

Leaf Blights—Leaf blights look somewhat like leaf spots but generally cause larger and more irregularly shaped diseased areas. Blights are common on almost all food and feed crops. The common name usually includes the word "blight" (southern leaf blight, early blight).

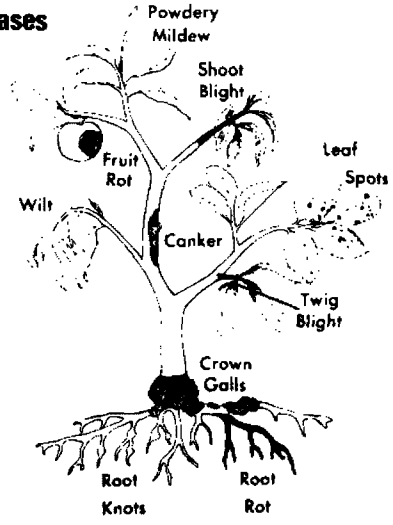
Rusts—Rust fungi often produce "pustules," which look like leaf spots. Rust pustules are masses of bright yellow, orange-red, reddish brown, or black spores being pushed through the leaf surface. With severe infections, the leaf withers and dies rapidly. Some types of rust also occur on stems.

Rusts are most common on grains, pasture grasses, and tree fruit crops. The common name usually includes the name of the crop affected and the word "rust" (stem rust of grains and grasses, leaf and cane rust of raspberry).

Powdery Mildew—Powdery mildew is a white to light gray, powdery or dusty growth on leaves. It may also occur on stems, fruits, and flowers. Affected leaves usually turn yellow, wither, and die. Powdery mildew is common on curcurbits, small grains, and fruits.

Downy Mildew—Downy mildew is a light gray, moldy growth on the underside of the leaf. It causes a pale green to yellow area on the upper leaf surface. Downy mildew fungi are important disease agents on some vegetables such as pepper, cabbage and soybeans.

Symptoms of Diseases



Wilts, Root Rots, and Crown Rots

These three distinct groups of fungal disease agents are usually soilborne. The fungi can survive for long periods of time in the soil. These organisms produce similar general symptoms (wilting and death of the plant). Close examination of a wilting plant will nearly always allow you to determine if it is caused by wilt, root rot, or a crown rot.

Wilts—Most wilt diseases are caused by fungi *(Fusarium* and *Verticillium),* although bacteria may produce similar symptoms. These parasites cause wilts on a wide range of crops. Wilt disease agents usually enter the plant through the roots. Some of the roots may be black and rot in the early stages of the disease. Extensive root rotting does not occur until after the plant is dead. A light- to dark-brown streaking can usually be seen in the stem of an infected plant.

Crown Rots—These disease agents usually attack the plant at or near the soil line. Affected plants are generally unthrifty with leaves smaller or lighter green than normal. Leaves usually turn yellow. In advanced stages of disease, the plant wilts and dies. The crown or base of the stem will be water-soaked, discolored, or decayed. A moldy growth with various colored fruiting bodies often forms in the diseased area. Crown rot can be important on some vegetable crops. Common names may include the words crown rot, collar rot, stem blight, stalk rot, or southern blight.

Root Rots—Some plants may wilt and die rapidly; others may be slow-growing, yellow, or stunted and may not die for some time after the symptoms appear. Roots are generally shortened, soft, and light brown to black. The outer portion of the root may slough off, leaving a stringlike center core. Every type of agricultural crop may be affected by root rots.

Stem Cankers

Stem cankers occur as well-defined, discolored areas on main stems or branches. These areas may be irregular or oval; they may be sunken or swollen. Some cankers crack open and expose the wood underneath. The foliage on stems with cankers is usually slow-growing, light green to yellow, and reduced in size. Infected stems often start growth later in the spring. The tips of infected stems may die back. Infected branches and plants may not die for

several months or even years after the disease first develops. Stem cankers are very important on tree fruit and nut crops.

Fruit Rots

Fruit rots are caused by many different kinds of fungi. All types of fruit are susceptible to rots. The symptoms vary from a superficial fungal growth on the external surface to a mushy, soft, watery rot. Rot may occur while the fruit is on the plant or after harvest. Some rots begin as a small spot sunken below the surface, containing spores or other fruiting bodies of the fungi. Some rots may cause a shriveling or a "dry rotting" of the fruit. Many rot-causing fungi occur only on one type of fruit; others may occur on different fruits.

Seed and Seedling Diseases

Seedling diseases are caused by soilborne fungi. They usually occur during the period from germination until shortly after emergence. If infection occurs before emergence, the seedling may never emerge. After emergence, seedling stems may be attacked at or slightly below the soil line.

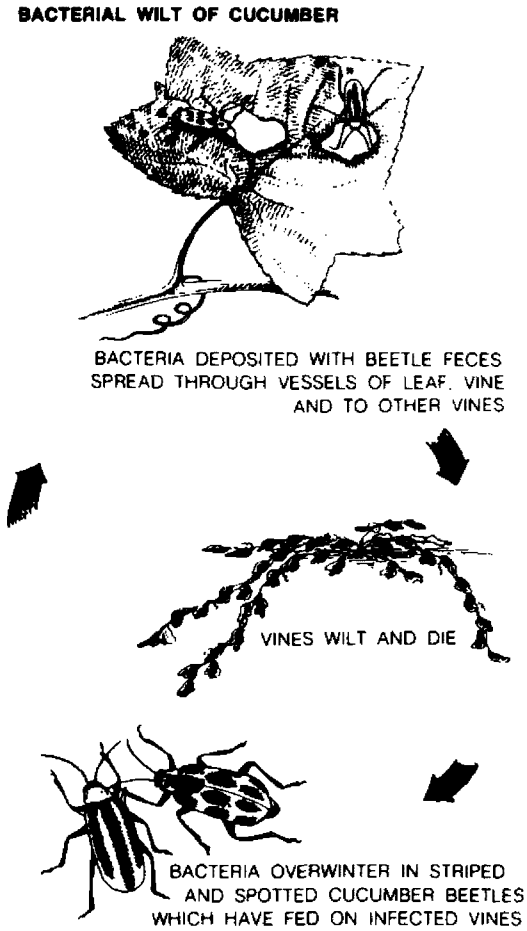
Symptoms include brown to reddish-brown or black cankers at the soil line which may girdle the stem. A second type of symptom is a soft, watery, rotted spot at the soil line. Seedling and seed diseases are most common in cool, wet soils. Any agricultural crop grown from seeds or seedlings may be affected. Among the common names for these fungal diseases are damping-off and seed rot.

Bacteria

Bacteria are microscopic, one-celled organisms. They usually reproduce by dividing in half. Bacterial numbers can build up fast under ideal conditions such as warm, humid weather. Bacterial disease agents can be identified by the symptoms they produce in plants or by signs of the bacteria's presence. Bacteria may attack any part of a plant both above and below the soil surface. Bacterial disease agents are spread from plant to plant and crop to crop by infected seed, man, insects, and other animal life including birds, snails, slugs, and worms, and by contaminated rain, irrigation water, equipment, tools, etc.

Bacterial Wilts

Bacteria which attack the water-conducting vessels of plants generally cause the same plant disease symptom—wilting. The water-conducting tissues may become so filled with bacteria that water can no longer be supplied to the foliage and the plant wilts. Often if the stems of infected plants are cut, a whitish bacterial ooze may form at the ends of the water-conducting vessels. Often the stem of the invaded plant is stained brown or black. Bacterial wilt may affect many types of agricultural plants, especially cucumbers, tomatoes, and cabbage.



Bacterial Blights, Leaf Spots, and Rots

Bacteria may attack the soft or succulent plant tissues and cause death of the affected areas. On leaves the symptoms are very similar to leaf spot and blights caused by fungal agents. Typically, the first symptom on the leaves appears as water-soaked spots, which finally turn to brown or "dead" areas. The rot of many fleshy roots, stems, rhizomes, and fruits is a

rapid, soft, wet, bacterial rot.

Bacterial blights, leaf spots, and rots may be distinguished from similar fungal diseases by presence or absence of spores (indicating fungus), or by the host which is affected. Often a microscopic examination is needed. Common diseases in this category include fire blight of apple and pear, angular leaf spot on cucurbits and tobacco, and soft rot of vegetables such as potatoes and onion.

Bacterial Galls and Overgrowth

Bacteria may cause abnormal cell division in a portion of a plant, causing tumors, galls, or witches-brooms. Often the symptoms are easily seen with the naked eye. These diseases may attack a wide variety of agricultural crops and are especially important on tree fruits and nut crops. Two common diseases in this group are crown gall and hairy root of apple.

Viruses and Mycoplasmas

Viruses and mycoplasmas are so small that they cannot be seen with an ordinary microscope. They are generally recognized by their effects on plants.

Viruses depend on other living organisms for food and to reproduce. They cannot complete their life cycle independently. They are transmitted by insects (usually aphids or leafhoppers), by infected plants, pollen, fungi, nematodes, or contaminated machinery and men.

Mycoplasmas are the smallest known independently living organisms. They can reproduce and exist apart from other living organisms. They obtain their food from plants. Most known mycoplasma diseases are transmitted by leafhoppers. Yellows diseases and some stunts are caused by mycoplasmas. Often it is difficult to distinguish between diseases caused by viruses and mycoplasmas and those caused by other plant disease agents.

Common symptoms of both virus-caused and mycoplasma-caused diseases include:

- mosaic—light green to yellow areas of the leaf, usually accompanied by abnormal leaf growth.
- vein banding—a light green to yellow band along leaf veins, which may later turn dark.
- ring spot—alternating rings of light green or yellow and normal green of the leaf.
- yellows—the entire plant or some parts are uniformly yellow.
- stunting—some or all parts of the plant are abnormally small. Stunting may occur in combination with all of the previous symptoms.
- rugose—leaves are crinkled and deformed.

Every type of agricultural crop may be affected by virus and mycoplasma diseases.

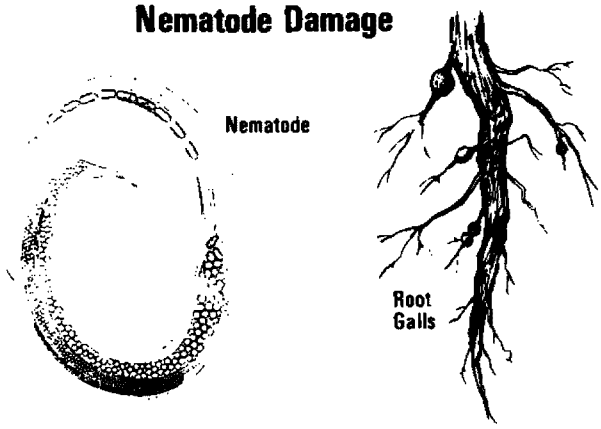
Nematodes

Nematodes are small, usually microscopic, roundworms. All nematodes that are parasitic on plants have a hollow feeding spear (stylet). They use it to puncture plant cells and feed on the cell contents. Their life cycle includes an egg, four larval stages, and an adult. In adverse conditions, some nematodes can assume an inactive form called a cyst which is difficult to penetrate or kill.

Nematodes may feed on plant roots, stems, leaves, and flowers. The most damaging root-feeding nematodes directly interfere with water and nutrient uptake. Nematode damage often goes unrecognized or is blamed on something else. Typical above-ground symptoms include stunting, yellowing, loss of vigor, and general decline.

Nematode injury in the field is rarely uniform. Damage often occurs in scattered areas of a field. Symptoms of injury become more obvious when soil moisture and fertility are low. Injury to the plant by nematodes may appear as galls, knots, stubby roots, and damage to or loss of feeder roots. Nematode infestations may be determined by having the still-living plant roots and surrounding soil examined in a diagnostic laboratory. There are many different species of nematodes which attack every type of agricultural crop.

Nematode Damage



Actual Length Equals 1/50 to 1/25 Inch

Parasitic Seed Plants

Dodders, broomrape, and witchweed are parasitic seed plants which are important disease agents on agricultural crops.

Dodders are leafless, orange to yellow twining vines. They do not have chlorophyll and must obtain their food from other living plants. Dodder germinates in the soil and produces a slender, yellowish thread. When it touches the host, it twines around its stem and puts out little suckers. As soon as the suckers are established on the host plant, the roots of the dodder shrivel and the connection to the soil dries up. Successful dodder parasites twine and spread from one plant to the next. They often appear as a tangle of matted orange hairs. Dodders parasitize clover, alfalfa, and flax and are becoming more important on some vegetables.

Broomrape is a leafless herb which appears above ground as a clump of whitish, yellowish, brownish, or purplish stems. It germinates from seed in the soil and produces a slender stem. The slender stem grows downward into the ground and penetrates the crown or root of the host plant. Upon contacting the host, the broomrape forms a tuberous enlargement and draws its food from the host. The flowering shoots appear above ground and a new generation of seeds are formed. Broomrape attacks tomatoes, lettuce, and other vegetables and may live on weeds between crop plantings.

Witchweed, as it appears above ground, has bright-green fuzzy stems and leaves and small, brightly colored flowers in red, yellow, or white. It germinates from seed only when a favorable host plant is present. The witchweed rootlet grows downward to the root of the host plant, penetrates the host root and feeds on the juices, plant foods, and minerals from the host. The flowers are produced above ground. Seeds mature and lie dormant in the soil until chemicals given off by a suitable host plant stimulate germination. Witchweed attacks grasses and sedges including corn, sorghum, wheat, oats, and barley.

Snails and Slugs

Upland snails and slugs are members of a large group of animals including oysters, clams, and other shellfish called mollusks. All mollusks have soft, unsegmented bodies and are often protected by a hard shell. Snails and slugs have two pair of antennae or feelers. Their bodies are smooth and elongate with a slimelike mucous coating.

Snails have a spiral-shaped shell into which they can completely withdraw when disturbed or when weather conditions are unfavorable. They are usually grey, but their shells vary from nearly white through brown to black and are often decorated with stripes or spots of contrasting colors.

SNAIL

Slugs do not have a true shell and must seek protection in damp places during daylight hours. Like snails, they emerge at night to feed. They range in length from ¼ inch to 8 to 10 inches, and may be whitish-yellow to black, usually with mottled spots or stripes.

Snails and slugs feed on plants by tearing holes in foliage, fruits, and soft stems, using a rasplike tongue. They may eat entire seedlings. Injury to plants is characterized by jagged holes in foliage, stems, and fruit. Snails and slugs also leave a trail of mucus on the surfaces which dries into silvery streaks. These silvery streaks may be undesirable on floral and ornamental crops and on those portions of crops to be sold for human food.

Snails and slugs deposit eggs in moist, dark places. The young mature in a year or more, depending on the species. Adults may live for several years. They overwinter in sheltered areas in colder regions of the United States. They are active year-round in warm regions and in greenhouses. They may attack many different agricultural crops. Common species include:

- spotted garden slug (8 inches),
- tawny garden slug (4 inches),
- grey or true garden slug (1 inch),
- brown garden snail,
- banded wood snail,
- white garden snail,
- subulina snail.

Weeds

Knowledge of the characteristics and life cycles of the weed species and the agricultural crops to be

protected is necessary for a successful weed control program. Weeds harm desirable plants by:

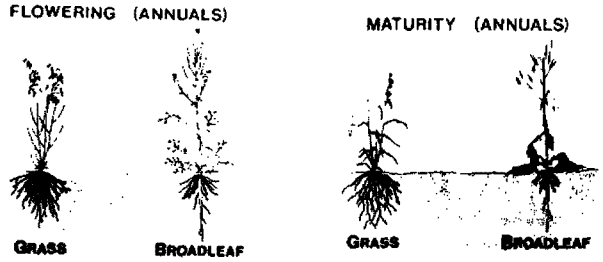
- competing for water, nutrients, light, and space,
- contaminating the product at harvest,
- harboring pest insects, mites, vertebrates, or plant disease agents, or
- releasing toxins in the soil which inhibit crop growth.

Development Stages

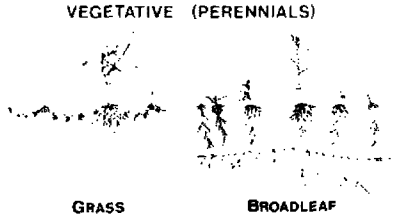
All plants have four stages of development:

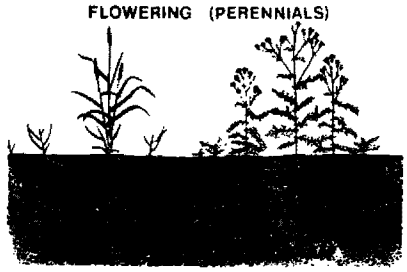
- seedling—small, vulnerable plantlets;
- vegetative—rapid growth and production of stems, roots, and foliage. Uptake and movement of water and nutrients is rapid and thorough;
- seed production—energy directed toward production of seed. Uptake and movement of water and nutrients slow and directed mainly to flower, fruit, and seed structures;
- maturity—little or no energy production or movement of water and nutrients in plant.

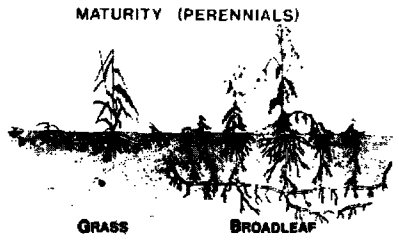
Annual plants complete all four stages of growth in one year. Common annual weeds include: foxtail, pigweed, lambsquarters, cheat, henbit, and cocklebur.



Biennial plants complete the seedling and vegetative stages of growth in the first year and the seed production and maturity stages in the second year. Common biennial weeds include: mullein, burdock, bull thistle, and wild carrot.

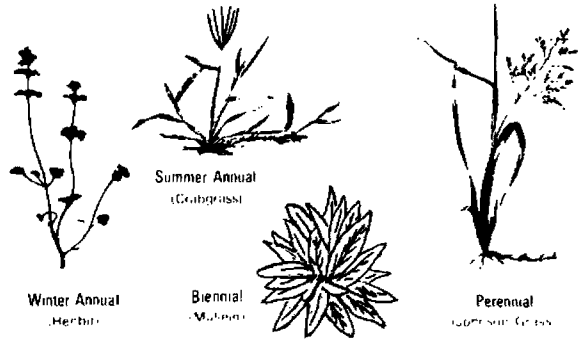






Perennial plants may complete all four stages in the first year and then repeat the vegetative, seed production, and maturity stages for several following years. Or the seed production and maturity stages may be delayed for several years. Some perennial plants die back in the maturity stage each winter; others, such as trees, may lose their leaves but do not die back to the ground. Common perennial weeds include: Johnson grass, field bindweed, wild garlic, dandelion, and sumac.

Annuals, Biennials, and Perennials



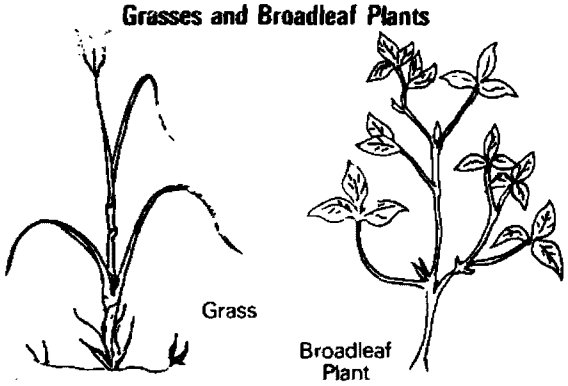
Weed Classification

Most pest plants are either grasses or broadleaves. The sedges, such as the nutsedges, are not classified as either grasses or broadleaves. However, they have similar characteristics to grasses and are often listed under grasses on the pesticide label. Grasses, sedges,

and broadleaves contain species with annual, biennial, and perennial life cycles.

Grasses

Grass seedlings have only one leaf as they emerge from the seed. Their leaves are generally narrow and upright with parallel veins. Most grasses have fibrous root systems. The growing point on seedling grasses is sheathed and located below the soil surface. Examples of grass weed species are: foxtail, Johnson grass.



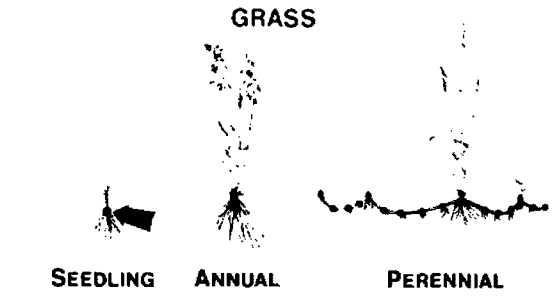
Broadleaves

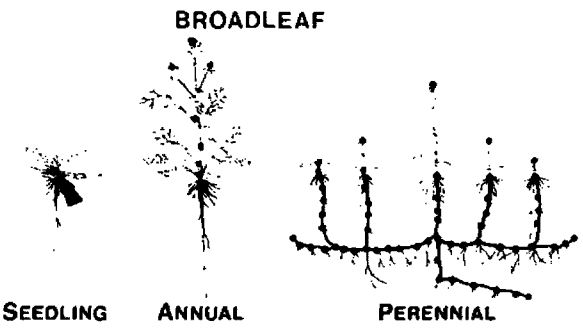
Broadleaf seedlings have two leaves as they emerge from the seed. Their leaves are generally broad with netted veins. Broadleaves usually have a taproot and a relatively coarse root system. All actively growing broadleaf plants have exposed growing points at the end of each stem and in each leaf axil. Perennial broadleaf plants may also have growing points on roots and stems below the surface of the soil. Examples of broadleaf weed species include: pigweed, mullein, dandelion, plantain, sumac, poison ivy.

Factors Affecting Control

In planning a weed control program, differences between weeds and the crop species, such as life cycles, foliar characteristics, and herbicide susceptibility must be exploited. Generally the more similar the crop and weed species are to one another, the more difficult weed control becomes. Plants differ in susceptibility due to:

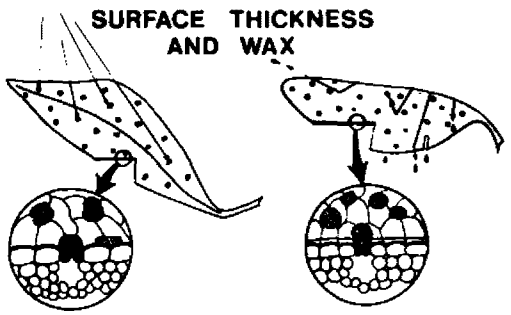
Growing Points—Those that are sheathed or located below the soil surface are not reached by contact herbicide sprays.





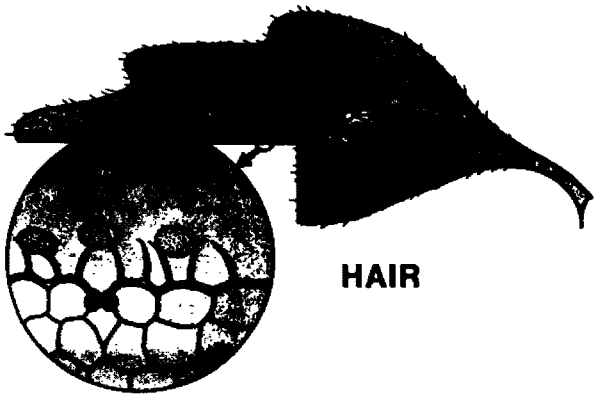
Leaf Shape—Herbicides tend to bounce or run off narrow upright leaves. Broad, flat leaves tend to hold the herbicide longer.

Wax and Cuticle—Foliar sprays may be prevented from entering the leaf by a thick wax and cuticle layer. The waxy surface also tends to cause a spray solution to form droplets and run off the leaves.

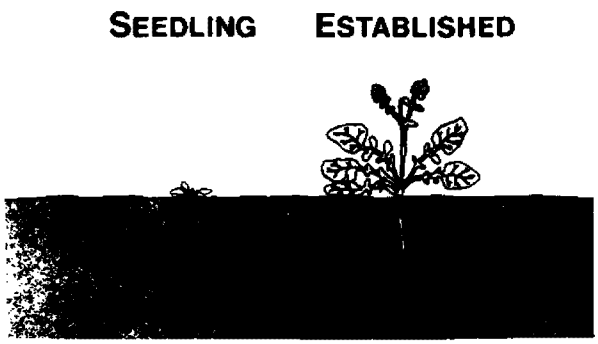


Dense Layer of Leaf Hairs—This holds the herbicide droplets away from the leaf surface.

Thin Layer of Leaf Hairs—This causes the chemical to stay on the leaf surface longer than normal.



Size and Age—Young, rapidly growing plants are more susceptible to herbicides than larger, more mature plants.



Deactivation—Certain plants can deactivate herbicides and are less susceptible to injury from these chemicals. Such plants may dominate over a period of time if similar herbicides are used repeatedly.

Stage in Life Cycle—Seedlings are very susceptible to herbicides and to most other weed control practices. Plants in the vegetative and early bud stages are very susceptible to translocated herbicides. Plants with seeds or in the maturity stage are the least susceptible to weed control practices.

Timing of Stages in the Life Cycle—Plants that germinate and develop at different times than the crop species may be susceptible to carefully timed herbicide applications.

Determining the Weed Problem

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

Weeds with physical characteristics; growth habits; soil, water, nutrient, and light requirements; and life cycles that closely resemble crop habits and requirements are usually the most serious competitors to crop species. Broadleaf weeds are often difficult to control in broadleaved crops, and grass weeds are often difficult to control in grass crops, because of the close physical resemblance and growth requirements. There are exceptions, however. Broadleaf weeds may be serious in grass crops and vice versa.

Weed Control Methods

Choose the weed control method which takes into account the differences between the crop and weed species. Be sure that the crop you are trying to protect is not susceptible to the weed control method that you choose. Read the herbicide label.

Cultivation—This is a traditional and often-used method to kill or control weeds in row crops. However, cultivation may bring buried seeds to the surface where they can either germinate and compete with the newly-planted crop or be spread to nearby fields. Cultivation may also increase soil erosion and may help to spread established plant diseases to uninfected areas of the field.

Planting Timing—Fall-planted crops compete well against summer annual weeds. Spring-planted crops compete well against winter annual weeds. Sometimes the crop planting date can be delayed until after weeds have sprouted and have been removed by cultivation or by herbicides.

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

Fire—Fire may be used to control limited infestations of annual or biennial weeds. Fire usually destroys only the tops of weeds and is not effective against perennial weeds.

Mulching—Mulching is used to prevent light from

reaching seedling weeds, thus preventing weed growth between crop rows or around trees and shrubs.

Mowing—Mowing may be used to reduce competition and prevent flowering and seeding of annual or biennial weeds. Mowing is often used in orchards to control weeds and prevent soil erosion.

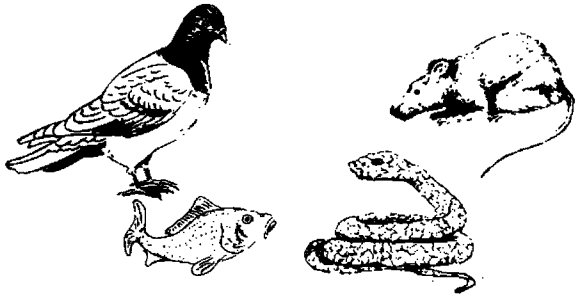
Flooding—Flooding has long been used for weed control in certain crops such as rice. The water covers the entire weed, killing it by suffocation.

Vertebrate Pests

Vertebrate animals may damage or destroy agricultural crops and equipment either in the field or in storage. Some pests, such as birds, rodents, raccoons, deer, or coyotes, may damage crops or livestock in the field. Beavers may flood low-lying cropland by building dams in creeks flowing through the area. Birds and rodents often contaminate and ruin more food in storage than they consume.

Barriers, trapping, repellents, and pesticides all help to control vertebrate pests. Pesticides cannot be used unless the specific pest can be legally controlled with pesticides under State and Federal laws. Always check with local authorities before using pesticides to control vertebrate animals. Local and State laws may prohibit the killing of some vertebrate animals such as birds, coyotes, and beavers.

Vertebrate Pest Animals

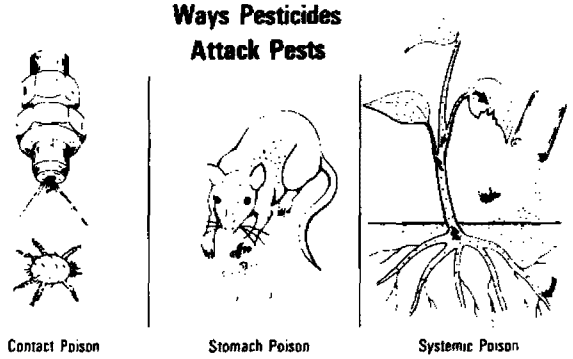


PESTICIDES

Insecticides

Insecticides are chemicals used to control insects. Insecticides such as malathion or parathion kill the insect by touching it (contact poison). Insecticides such as lead arsenate and Paris green have to be swallowed to be effective (stomach poison). Insecticides called systemics, such as dimethoate or aldicarb, are absorbed, injected, or fed into the plant to be protected. When the insect feeds on a plant protected by a systemic insecticide, it eats the chemical and is killed. Some insecticides, such as demeton or aldicarb, have all three properties. They can kill either by contact or if eaten, and they are systemic.

Ways Pesticides Attack Pests



Insecticides vary in the number of different kinds of insects that they kill. Some insecticides, such as methoxychlor or carbaryl, are highly selective and kill only certain kinds of insects. Sometimes you can choose insecticides that will kill only the pest insect and not harm beneficial insects in the area. Many insecticides, such as parathion or pyrethrins, are nonselective and kill most kinds of insects. Every insecticide is different. One that is highly effective against one pest may not be effective against another insect.

Insecticides also vary in how long they last as a killing agent after they have been applied. Some chemicals, such as chlordane, are persistent, remaining active for weeks or months. These insecticides are often used when control over an extended period of time is needed. Other insecticides, such as carbaryl or pyrethrins, are nonpersistent and break down quickly (several hours to a few days) into byproducts.

Read each insecticide label carefully to determine the insects it will control and how to use it properly. Always choose the safest insecticide for your situation.

Miticides

Miticides are chemicals used to control mites. Usually these are contact poisons (such as acarol,

chlorobenzilate, or Plictran) or systemic poisons (such as demeton). Thorough coverage is usually necessary to control the pests. A few, such as Acrex, are stomach poisons. Miticides are similar in action to insecticides. Often the same chemical, such as carbofuran or parathion, kills both insects and mites. A miticide may be selective, like Plictran or chloropropylate, or nonselective, like Acrex or chlordimeform. A miticide may also be persistent, like acarol or chloropropylate, or nonpersistent like Acrex or chlorobenzilate.

Fungicides

Fungicides are chemicals used to control the fungi which cause plant diseases. All fungicides are contact or systemic poisons. Most fungicides, such as captan or maneb, must be applied to cover all plant surfaces in order to control fungus organisms. Systemic fungicides such as benomyl move in the plant to be protected.

There are two approaches to the use of fungicides. One is to prevent the plant from getting the disease. Used this way, fungicides are called protectants. They are applied before the disease gets a start. This type of fungicide, such as zineb, thiram or Bordeaux mixture, is the most commonly used. Some fungicides control the fungi after they appear on (or in) the plant. This use of fungicides is called "eradication." Eradicants are much less common than protectants. Benomyl may be used as both eradicant and protectant in some disease control programs.

Bactericides

The word "fungicide" is often used to describe all chemicals which are used to control plant disease agents. The correct term for chemicals used to control bacteria-caused plant diseases is bactericide. Some chemicals, such as fixed copper, help to control both fungi and bacteria. Others, such as streptomycin, are only effective against bacteria.

Because bactericides are contact poisons, thorough coverage is necessary to control all the bacteria. Bactericides are similar in action to fungicides and are applied either as protectants or eradicants. Sometimes the same chemical may be both a protectant and an eradicant.

Controlling Viruses and Mycoplasmas

No chemicals are presently used to directly control viruses or mycoplasmas that cause plant diseases. Control of these plant disease agents may be accomplished by:

- Using disease-free plants—"certified" means that plants have been inspected during the growing season and found free of certain diseases.
- Using plants or seeds resistant to specific virus or mycoplasma diseases.
- Eliminating alternate plant hosts.
- Using cultural practices such as crop rotation.

Nematicides

Nematicides are chemicals used to control nematodes. Because most nematicides are contact poisons, thorough application is necessary to protect the plant against nematodes in an area. Most of the early nematicides were soil fumigants. These must be applied before planting because they kill most living organisms in the soil. More recently, several contact nematicides have been developed. They kill nematodes without injury to newly seeded crops or perennial plants. Some of these contact nematicides are also effective insecticides. Crop rotation and the use of nematode-resistant plant varieties can be effective methods of controlling nematodes. Some common nematicides are carbofuran, aldicarb, Nemacur, and Mocap.

Controlling Parasitic Seed Plants

Parasitic seed plants may be controlled through the use of herbicides. Dodders, broomrape, and witchweed all may be controlled with certain herbicides. Special attention must be paid to the type of crop to be protected. The same herbicide may not be used with every crop host. Other means of control include avoiding seed that is infested with parasitic plants and controlling the plants before seed is set for the next season.

Molluscicides

Pesticides used to control snails and slugs are

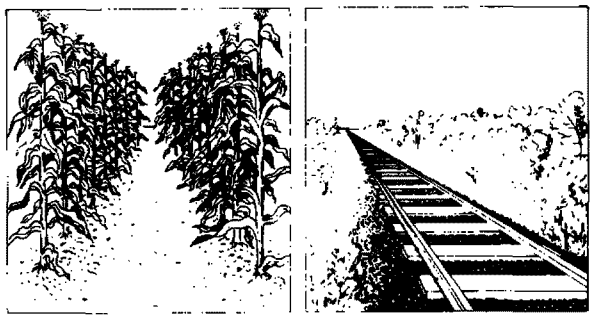
called molluscicides. They are formulated as baits, dusts, or sprays. Baits should be placed in areas where birds and other non-target animals cannot reach them. Dusts and sprays are contact poisons and should be directed at the surfaces which snails and slugs may crawl over or feed upon. Common molluscicides include metaldehyde, arsenic, and Bayluscide.

Herbicides

Both the use of a herbicide and the way it is applied depend upon these characteristics of the active ingredients:

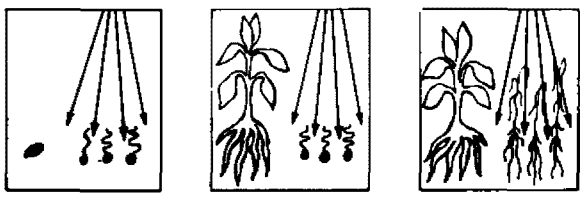
- foliage-absorbed or root-absorbed,
- contact or translocated,
- selective or nonselective,
- persistent or nonpersistent.

Selective vs Nonselective Herbicide



Selective Nonselective

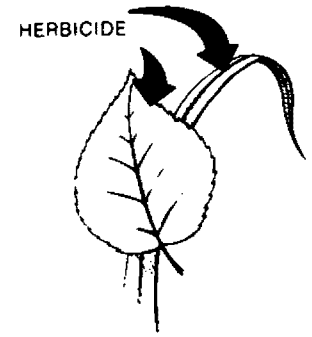
Preemergence and Postemergence



Preemergence to the Crop and Weeds | Postemerged Crop Preemerged Weeds | Postemergence to the Crop and Weeds

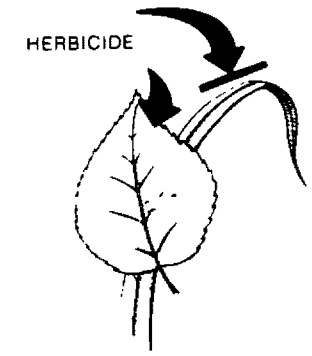
Foliage–Contact–Nonselective–Nonpersistent

These herbicides kill all foliage contacted. Because they are nonselective, they must be applied in the absence of a crop or as a spray directed towards certain plants or plant parts. There is little or no translocation to underground or shaded parts of the weed. Grasses and perennial broadleaved weeds with below-ground growing points will recover after treatment. Seedling plants and annual and biennial broadleaved weeds can best be controlled with these herbicides. Examples: dinoseb, paraquat, diquat.



Foliage–Contact–Selective–Nonpersistent

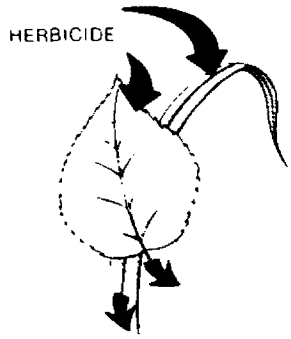
These herbicides kill certain kinds of plants when they contact the foliage. Differences in foliar characteristics of crop and weeds determine the selectivity. These herbicides are most effective on seedling weeds. Established grasses and biennial and perennial broadleaved weeds may regrow after the foliage is killed. These herbicides are generally not translocated and some may have a short effective life in the soil. Examples: endothall, dinoseb-salts, Stoddard solvent.



Foliage–Translocated–Nonselective–Nonpersistent

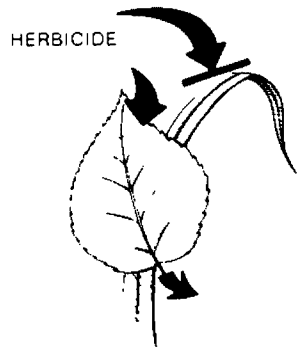
These herbicides are absorbed by the foliage and translocated throughout the plant. Since they are nonselective, they cannot be applied when a crop is

present, but they can be used before planting or after harvesting. Examples: TBA, glyphosate.



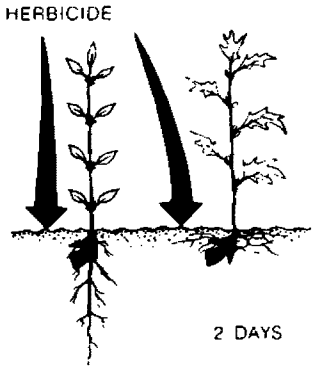
Foliage–Translocated–Selective–Nonpersistent

These herbicides are applied to the foliage and are absorbed and translocated throughout the living portions of the plant. Their selectivity results from the ability of some plants to deactivate the herbicides and therefore they can be applied over the top of the crop. Selective translocated herbicides are most effective when applied during the vegetative stage of development of the weed. Examples: 2, 4–D; 2, 4, 5–T; MCPA; silvex; dalapon.



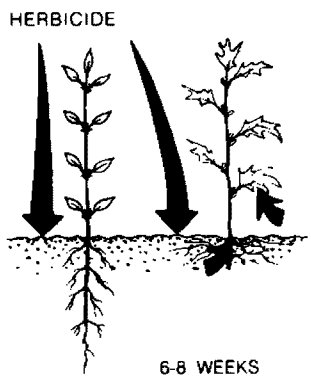
Soil–Nonpersistent–Nonselective

A small number of herbicides belong to this group. The most widely used are fumigants, but there are other chemicals also. Fumigants are gases at normal air temperature and escape into the air if the treated soil is not covered. Most fumigants are released under a sheet of plastic or other gas-tight cover which remains for about 24 hours. All weeds and other plants, including seed, are killed. These are always preplant applications. Examples: carbon bisulphide, chloropicrin, methyl bromide, calcium cyanamide.



Soil–Nonpersistent–Selective

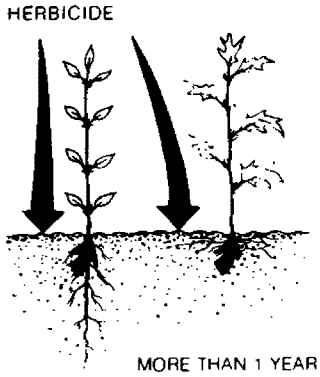
These herbicides are applied to the soil before, at, or immediately after planting. Their active residues last less than a year. Most herbicides used for vegetable and grain crops are in this group. Since the crop is present at the time the herbicide is applied, or is planted soon after application, the herbicide must be selective. The selectivity is usually due to differences in the internal chemistry between the crop and weed species. These herbicides are often called preemergence herbicides or preplant, soil incorporated herbicides. Examples: CIPC, EPTC, CDAA, substituted ureas (diuron, linuron, monuron), TCA, amiben, trifluralin, atrazine at low rates.



Soil–Persistent–Nonselective

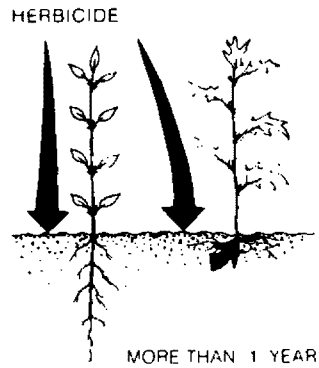
These herbicides are used to control all plants in noncrop situations to maintain a bare ground. They are used on parking lots, around warehouses, along fences and highway guardrails, and in storage areas. Examples: bromacil, boron, sodium chlorate, and

simazine and atrazine at high rates.



Soil–Persistent–Selective

These herbicides have a low solubility in water and do not leach readily, so they stay near the soil surface. The selectivity is often based on the inability to reach deep-rooted crops. They may be applied to the foliage of the weeds, although most of the herbicide is eventually absorbed through the root system. They persist and will give weed control for more than a year. Some can be used to control weeds in fruit trees, nut trees, and grapes. Examples: terbacil, picloram, dichlobenil, simazine at low rates.



Controlling Vertebrate Pests

Pesticides used to control vertebrate pests are often named for the type of animal they control. Common pesticide categories include:

- rodenticide—rodents,
- avicide—birds,
- piscicide—fish, and
- predacide—predatory animals.

Pesticides for control of vertebrates may be fumigants, chemical repellents, reproductive inhibitors, baits, or broadcast poisons.

Fumigants kill vertebrate pests in burrows, storage bins, or other areas which can be easily sealed. The pests cannot escape and are killed by inhaling the toxic gas. Examples are cyanide and methyl bromide.

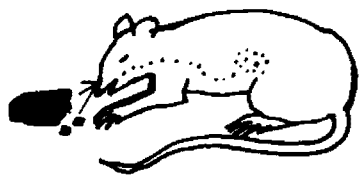
Chemical repellents may make treated areas unacceptable to pests by odor or taste and thus deter damage. In this way, the offending animal may be forced to find a different location or new food source. Examples are Mesurol, used as a repellent on seeds; and napthalene, which repels by odor.

Reproductive inhibitors that control vertebrate populations show considerable promise with some species. Research is continuing and the future may see birth control for pest species as an acceptable means of combating pest problems. An example is Ornitrol on pigeons.

Poison baits usually are in one of two categories:

- multiple-dose poisons (usually anticoagulants), which must be eaten repeatedly during a period of several days to be effective. Examples are Warfarin and Pival for rodent control.
- single-dose poisons, which kill quickly if enough is consumed at one feeding. Place baits so that they will be eaten by the target pests but not by other animals or people. Avoid secondary poisoning by picking up carcasses before dogs, cats, or protected predatory animals find them. Examples are Avitrol for bird control, and zinc phosphide and Vacor for rodent control.

POISONOUS BAITS



Broadcast poisons—A few pesticides registered for use on vertebrate pests are formulated as wettable powders or emulsifiable concentrates. They are sprayed on or released into the application site. The target species present in or entering into the application site are controlled. Piscicides are usually in this category. The chemical is released into the pond or stream and susceptible aquatic species are controlled. Examples are endrin for rodent control and rotenone for fish control.

Few pesticides are registered for use on vertebrates. Registered pesticides have labels which name the offending or target species, details of application, and precautions to be taken. Poisons or repellents may not be used on species other than those listed on the label. Pay special attention to State and local regulations, which may be more stringent than Federal regulations.

ENVIRONMENTAL PROTECTION

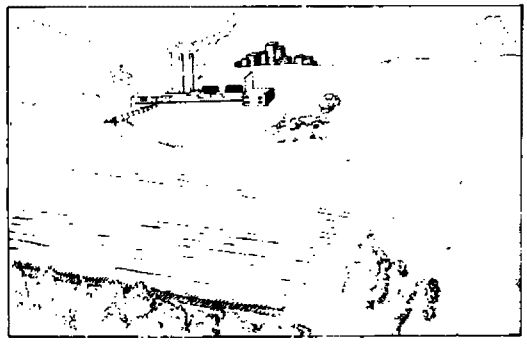
Soil and Water

A number of factors are involved in the risk of soil and water contamination. On crops where repeated pesticide applications are necessary, pesticides (especially those that are persistent, such as lead arsenate or copper) may build up in the soil.

On row crops where tilling is common and the water drains into aquatic areas, runoff of contaminated soil particles and pesticides is likely. Do not apply pesticides just before predicted heavy rains or just before some types of irrigation.

Some protectant fungicide sprays should be applied before and during a rain. Some herbicides should be applied just before rain. However, heavy rains cause runoff and tend to wash the pesticide away from the target area. The runoff can carry the pesticide into sensitive areas where crop injury may result. Runoff may also reach farm ponds, streams, and waterways, causing contamination, fish kills, or injury to domestic animals such as dairy cows.

Pollution by Pesticides



Many combinations of these and other factors may lead to soil and water problems. Use good judgment and seek good professional advice. Be aware that as the risks in a given situation arise, you may need to consider changing time of application. pesticides, or your normal application method.

Drift

Drift is a main cause of contamination of nontarget areas. Factors affecting drift include:

- pesticide formulation,
- particle size,
- velocity and direction of wind,
- type of application equipment used,
- volatility of the pesticide, and
- temperature inversions.

A temperature inversion exists when cool air is trapped close to the ground by a warm layer of air. Particles released into the cool air layer at ground level have minimum upward movement. The slightest air movement can cause the particles to drift for great distances before they fall.

In addition, the toxicity of the pesticide and the sensitivity of the nontarget area will influence the potential damage.

When other conditions are the same:

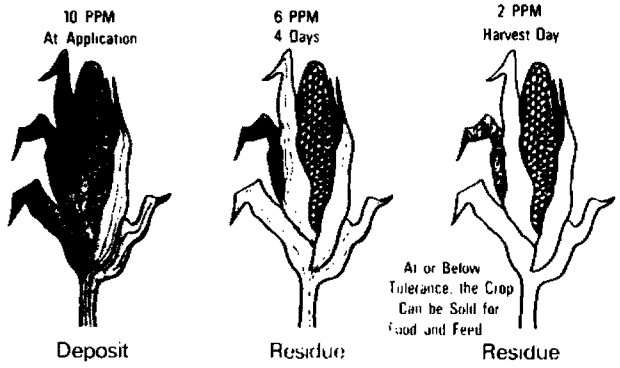
- Smaller droplets or dust particles drift farther than larger ones.
- There is more chance of drift with air blast sprayers than with boom sprayers.
- There is more chance of drift with high-pressure sprayers than with low-pressure sprayers.
- Low-volume concentrates are more likely to drift than high-volume dilutes.

- ULV sprayers have one of the greatest potentials for creating drift because they produce very small droplets.
- The chance of wind effect and drift increases as the boom or outlet is raised above the crop.
- Air currents which may cause drift are usually greater during the middle of the day than in early morning or late afternoon.
- High pressure and small nozzle openings produce fine spray droplets which drift more readily.

Reentry and Preharvest Intervals

The preharvest interval is the least number of days allowed between the last pesticide application and the harvest day. "Days to slaughter" and "days to grazing" intervals apply to livestock feeding. Whenever these intervals are applicable, they are listed on the pesticide label. You should advise your customer of the number of days involved for each.

Days to Harvest



(Shading Denotes Pesticide Residue)

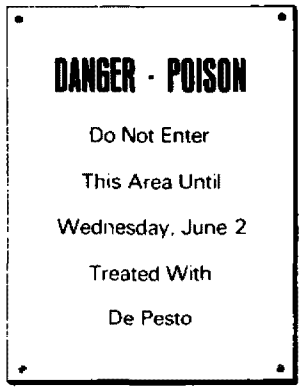
Days to Slaughter

(Shading Denotes Pesticide Residue)

The worker reentry period is the minimum time between the last pesticide application and reentry of workers into the field without protective clothing. The worker reentry interval will be listed in the special "reentry" section on the new format pesticide label. You should advise your customer of the number of days involved and the type of protective clothing that workers must wear if reentry is necessary before the period runs out. Workers may not reenter treated fields without proper protective clothing at least until the sprays have dried or dusts have settled. Proper (and legal) minimum protective clothing for early worker reentry includes a hat or other suitable head covering, a long-sleeved shirt and long-legged trousers, shoes, and socks.

Inform your customer of these intervals and regulations. Misunderstanding, injury, and possible litigation may result if your customer is not properly informed.

Reentry Sign



Phytotoxicity

Phytotoxicity is injury to plants which can range from slight burning or browning of leaves to the death of the whole plant. Such injury to plants by pesticides may be the result of:

- excessive dosage,
- direct application to a susceptible plant,
- drift onto the plant of spray, dust, or vapor,
- runoff from a treated field,
- persistent soil residues, or
- improper formulation.

Injury to the plant may appear as:

- dead, burned, or scorched spots on or at the tip of leaves,

- russeting of fruit,
- misshapen fruit, leaves, or plants,
- off-color,
- stunting,
- delayed development,
- poor germination, or
- complete death of the plant.

Unfortunately, these signs of chemical injury often do not appear until several days after exposure to the pesticide. If they do appear, they are not always clear-cut and often may be confused with other problems. It may be necessary to call on experienced individuals to help identify the cause.

The likelihood of plant injury resulting from the use of a pesticide varies with:

- the chemical,
- the formulation,
- the concentration,
- the combination of chemicals,
- method of application,
- growing conditions, or
- the growth stage or condition of the plant.

Emulsifiable concentrates, which contain solvents, are more likely to cause injury than wettable powders. Mixtures of pesticides are more likely to cause injury than the same materials applied individually. High-pressure applications may cause injury when low-pressure applications would not.

Plants growing under stress conditions, such as those in shallow soils or wet spots, are more susceptible to injury than healthy plants. Young, tender, fast-growing plants with much new growth tend to be more susceptible to injury. Some varieties are more sensitive than others.

Community Problems

Agricultural land close to urban development may have greater community problems than an all-agricultural area. Drift, phytotoxicity, and other nontarget injury can cause problems in any community, but the denser the human population or livestock adjoining treated areas, the greater the risk of injury to humans or domestic animals.

When the crops on adjoining land are sensitive to the pesticides you are using, be especially careful to prevent drift.

Aquatic areas, such as ditches, ponds, or lakes, are particularly sensitive to pesticide contamination. Where reservoirs for community water supplies, fishing, and other public uses are involved, careless pesticide application may cause fish kills or contaminated water supplies.

*U.S. GOVERNMENT PRINTING OFFICE : 1978 0-720-335/6040