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Key Questions About Integrated Pest Management (IPM)

- What are the benefits of IPM?
- How would you start an Integrated Pest Management program on your farm?
- How do you decide if a pesticide is economical to use or not?
- How is managing a plant disease different from managing weeds? from managing insects?

What Is Integrated Pest Management?

Pesticides alone will not solve the problem of controlling pests. In fact, the widespread use of pesticides has created new problems, including damage to the environment, hazards to human health, and increased resistance of pests to some pesticides.

Integrated Pest Management (IPM) has been developed as a way to control pests without relying solely on pesticides. IPM is a systematic plan which brings together different pest control tactics into one program. With IPM, a farmer uses pesticides as one tool in an overall pest control program.

To better understand the concepts of IPM, let's look at what each of the words in the term *Integrated Pest Management* means:

Integrated: a focus on interactions of pests, crops, control methods, and the environment rather than on individual weeds, insects, or diseases. This approach considers all available tactics and how they fit in with other agricultural practices.

Pest: a species that conflicts with our profit, health, or convenience. If a species does not exist in numbers that seriously affect these factors, it is not considered a pest.

Management: a way to keep pests below the levels where they can cause economic damage. Management does **not** mean eradicating pests. It means finding tactics that are both effective and economical and that keep environmental damage to a minimum.

Control Methods Used in IPM

IPM methods include cultural, biological, mechanical, chemical, and legal controls. None of these alone can solve all problems. Each has benefits and drawbacks. For example, tillage helps in weed, disease, and insect control, but can also result in soil erosion. The purpose of IPM is to help you make decisions based on careful consideration of costs, risks, and benefits.

Cultural Control

Many practices used in producing crops can also help reduce pest problems. Here are some examples:

Tillage buries crop residues containing insects, diseases, and weed seeds, and disrupts root systems of perennial weeds. Drawbacks: stimulates weed seed germination; can cause soil erosion.

Mulching with plastics or straw controls weeds. Drawback: high cost of equipment and labor.

Burning crop residues reduces diseases. Drawbacks: reduces soil cover, which may lead to soil erosion; air pollution.

Resistant varieties have characteristics that protect them from diseases or insects. Example: a chemical produced in young corn plants gives them resistance to the European corn borer. Drawback: new strains of diseases or insects may develop the ability to attack the variety.

Tolerant varieties have the ability to produce a yield despite attack or injury from insects or diseases. Example: corn varieties that can regrow roots after a corn rootworm attack.

Crop rotation means growing different crops in sequence to provide better weed and insect control, reduce levels of disease (especially those that survive on crop residue), and improve fertility. Example: rotating corn with soybeans to control corn rootworm.

Altering planting or harvest dates can reduce the impact of pests. Examples: late planting to avoid sunflower midge; cutting alfalfa early during alfalfa weevil infestations. Drawback: possible reduced yields and quality.

Controlling alternative hosts means controlling weeds and crops that harbor pests. Example: weedy grasses in corn attract egg-laying armyworms, stalk borers, and hopvine borers. Drawback: many of these alternative hosts also support natural enemies of the pests.

Sound agronomic practices that promote vigorous crop growth reduce risk of injury and increase the crop's ability to withstand pests.

Biological Control

Another method of controlling pests is to use the pest's natural enemies. In general, there are four types of natural enemies: predators, parasitoids, diseases, and herbivores.

Predators feed on insects. Example: seven-spotted ladybird beetles kill aphid pests of small grains and alfalfa.

Parasitoids are wasps or flies that lay their eggs on insect hosts; the young kill the host as they develop. Example: the wasp *Macrocentrus grandii* lays its eggs on the European corn borer.

Diseases that attack insects often occur in epidemics, killing off large numbers of insect pests. Example: the fungus *Beauveria bassiana* can cause local populations of European corn borers to die off.

Herbivores are insects that feed on weeds. Example: the weevil *Rhynocyllus* has been introduced to feed on musk thistle seeds.

Strategies using biological control include:

- **Create a welcoming environment** for natural enemies. Examples: strip harvesting alfalfa to allow natural enemies to stabilize; avoiding pesticides, if possible, to preserve insect predators and parasitoids.
- **Release natural enemies** into the environment. Some are released like an insecticide but are more selective in their action. Examples: the bacteria *Bacillus thuringiensis*, available locally, is very effective against the European corn borer; the parasitic wasp *Trichogramma* attacks European corn borer eggs and can be applied by air on certain high-value crops like peppers and sweet corn.

Mechanical and Physical Controls

Devices and machines can be used to control pests or to alter their environment. Mechanical or physical controls include:

- Traps for rats, mice, gophers, and birds.
- Light to attract or repel pests; bug zappers.
- Sound to kill, attract, or repel pests.
- Barriers such as screens in homes and livestock shelters.
- Radiation to sterilize or kill pests.
- Cold or heat to kill pests. Example: cooling down grain bins over the winter stops activity of grain-infesting insects and molds.

Chemical Control

Despite concern over their use, pesticides are still important in many IPM programs. Problems arise when people rely too much on pesticides. IPM seeks to restore balance so that pesticides are used only when they are really needed.

Be aware of the possible *benefits* and *risks* of using pesticides. Then you can wisely select when, where, and how to use pesticides to your best advantage in an IPM program.

Benefits of pesticides:

- Effective and reliable against a wide variety of pests.
- Quick acting—when a problem reaches economically damaging proportions, pesticides can provide a rapid cure.
- Economical when used properly.
- Easy to use.
- Easily tested—for new pests, it is easier to test and incorporate pesticides in a control program than to develop resistant varieties or import natural enemies.

Risks of pesticides:

- Pest may develop resistance to the pesticide.

- Injury to applicator and others.
- Impacts on nontarget organisms, including natural enemies of pests, pollinators, wildlife, and plants.
- Environmental contamination, such as residues in food and water.
- Safety hazards in production, transportation, and storage.

Legal Control

Actions can be taken under federal, state, or local laws to slow or stop the spread of certain plant pests, especially those that are brought in from other areas. These actions include quarantine, inspections, compulsory crop or product destruction, and eradication of pests. Example: legal controls against the Mediterranean fruit fly have included insect eradication programs and quarantine and embargoes on affected fruit.

How to Set Up an IPM Program

Planning is at the heart of an IPM program. Every crop has pests that need to be considered. If you wait until problems arise during a growing season, you'll end up relying on pesticides more and more.

A good Integrated Pest Management program has four parts: 1) identifying problems; 2) selecting tactics; 3) considering economic and environmental factors; and 4) evaluating the program.

Identify Problems

You have to know what's happening in your fields before you can make good management decisions. You should scout your crops often and on a regular basis to identify problems. Scouting is, in fact, the key feature of any IPM program. By scouting, you will be able to detect potential problems early. The earlier you discover a problem, the better your chances are of avoiding economic losses.

To scout effectively, you have to:

Know the crop's growth characteristics to recognize abnormal or damaged plants.

Identify the cause of the problem to know what kind of pest you are dealing with. If you encounter something you cannot identify, contact your county extension educator.

Determine the stage of growth of the pest and the crop. This is essential for proper timing of control methods.

Decide whether the infestation is increasing or decreasing.

Assess the condition of the crop.

Map out problem areas. It may be possible to limit the area that needs treatment.

Use the right scouting method for the specific pest.

Select Tactics

Once you've identified the problem, you should consider how to control it. Your goal in selecting control tactics is to use methods that are effective, practical, economical, and environmentally sound. To select the best control tactics, you have to:

Understand the life cycle and habits of the pest. Some control methods will work only if they are used at the right time.

Decide whether the infestation is serious in terms of economic loss.

Compare the costs and benefits of various control methods.

Make plans for the future. Not every part of an IPM program can be put into effect immediately. Some tactics, such as planting resistant varieties or rotating crops, require long-range planning.

Consider Economic Factors: Know When It Pays to Use a Pesticide

Despite efforts to avoid using chemicals, there are times when only pesticides can control the damage. Even so, it may not pay to use them. Pesticides should be used in an IPM program only when the benefits (yield, quality, aesthetic value) exceed the costs of control. Otherwise time and money are wasted.

It's not easy to figure out when it pays to use pesticides. There are many variables: the pest population, variety, crop growth stage, value of the crop, weather, and cost of the control. The following economic concepts are helpful in determining the point at which it pays to use pesticides:

Economic damage (ED) occurs when the cost of preventable crop damage exceeds the cost of control. For example, if corn is worth \$2.00 a bushel and an insecticide costs \$14.00 an acre, then economic damage occurs when insect damage causes a yield loss of seven or more bushels an acre.

Economic injury level (EIL) is the lowest pest population that will cause economic damage. For many pests it is important to use control measures *before* this level is reached.

Economic threshold (ET) is the pest population level at which a control tactic should be started to keep the pest population from reaching the EIL. (The ET is also called the action threshold.) Economic thresholds have been established for a number of crop/pest systems, in particular those involving insects. This information is available from the University of Minnesota Extension Service. It has been harder to develop economic thresholds for weeds and diseases, but research is being done to develop ETs for these systems.

Evaluate Your IPM Program

Evaluation means deciding how effective a program is and whether any changes are needed. To evaluate an IPM program, you should:

Monitor your fields and keep records. Each time you visit your fields, make a note of crop and pest conditions—record crop yields and quality and record any counts on pest populations.

Record control measures. Records should include dates, weather conditions, pest levels, application rates and timing, and costs. Good records are a guide if the same problem occurs. They are also a good legal safeguard.

Compare effectiveness. Whatever control tactics are chosen, use a different method on some strips. That way you can compare them; which worked better, taking into account costs and environmental impacts?

Managing Insects

There are more insects in the world than any other animal. More than one million species have been identified. Of these, less than 10,000 species can be considered pests, and very few of them are serious agricultural pests. Many insects are important as scavengers, predators, parasites, and plant pollinators.

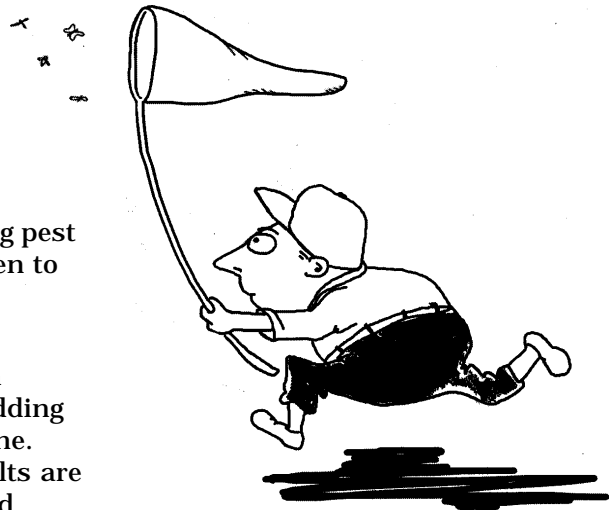
How Insects Grow and Reproduce

Before trying to control insect pests, you need to understand how they grow and reproduce. Knowing pest life cycles and development allows you to plan when to scout fields and when to apply control measures.

Insects grow through a process of change called *metamorphosis*. Insects have an external skeleton (exoskeleton). They can only grow in steps by shedding their old exoskeleton and forming a new, larger one. This process is called *molting*. Stages between molts are called *instars*. Some insects, like grasshoppers and leafhoppers, change gradually. Their eggs hatch into *nymphs*, which look like the adults except that they are sexually immature and lack wings. Other insects, like beetles, moths, and butterflies, undergo a drastic change in body form—from eggs to *larvae* to the adult form. In different stages, the insect's habitat and food sources may change completely. For example, corn rootworm larvae feed on corn roots in the soil, but the adults feed on corn silks and the pollen of many plants.

Temperature has a direct effect on the growth and development of insects. Each species has a temperature range in which it develops. Within this range, the higher the temperature, the faster the insect develops and grows. But at very low or very high temperatures, insect development stops. The insect may die, or may resume development when the temperature returns to its normal range. Knowing the temperature ranges of an insect can help you predict pest development, so you will know the best time to scout and to use control measures.

Some insects overwinter in Minnesota by suspending development and entering a resting state called *diapause*. Insects can diapause in any stage but it is most common in egg and larval stages. Some insects cannot overwinter in Minnesota. They migrate to the south and return to Minnesota each spring and summer.



In the adult stage, insects have three main functions: to reproduce, to spread to new areas, and to search out homes for their offspring.

Reproduction. To find a mate, some insects use chemical cues released from a prospective mate or from a host plant or animal. A chemical released to attract a mate is called a *pheromone*. Insects have amazing reproductive capacities. One female may lay anywhere from a few to several thousand eggs in her lifetime. For example, the western corn rootworm lays from 500 to 1,500 eggs. In addition, some species produce two or more generations in one season.

Spreading to new areas. Wings enable adult insects to move to new habitats, an important ingredient in the survival of the species. The distance each species can travel ranges from a few feet to thousands of miles. For example, a female gypsy moth cannot fly at all, European corn borer and corn rootworm beetles can fly several miles, and monarch butterflies migrate to Mexico and back to Minnesota.

Selecting a site for laying eggs is perhaps the most important thing a female insect does. Young nymphs or larvae cannot move very far, so where the female chooses to lay eggs determines whether the offspring will survive. Female insects use all their senses—sight, smell, taste, and touch—to pick the right spot.

Limits on reproduction. Despite their amazing capacity to reproduce, insect populations are usually kept in check by such limiting factors as weather, natural enemies, and relative lack of food. Major pest outbreaks occur when the balance between the limiting factors and the insect's reproductive capacity shifts in favor of the insect. One of the ways this imbalance occurs is when humans create specialized environments, such as farms and lawns. When we confine livestock or plant large acreages of single crops, we create settings favorable to some insects and at the same time reduce or eliminate those insects' natural enemies.

When Is an Insect a Pest?

Insects are considered pests when they cause economic or aesthetic losses or when they create inconvenience, annoyance, or health problems. Before using control measures, you need to know whether the insect really is a pest and whether the damage it causes is serious enough to justify control tactics. Unfortunately, people often try to control insects because the damage is easy to see, not because of the economic impact. For example, insects that feed on leaves, like the Colorado potato beetle, sunflower beetle, and green cloverworm, are often unnecessarily treated with insecticide because the damage is so visible.

Insects can cause injury to plants, animals, and humans in a variety of ways:

Plants. Insects injure plants by reducing the yield or quality of crops or the beauty and economic value of horticultural crops. Insect injury to plants includes:

- Chewing on leaves, fruits, seed, and roots.
- Tunneling in stems, leaves, or roots.
- Sucking plant juices from leaves, stems, roots, fruits, and flowers.

- Initiating galls or other plant malformations.
- Spreading plant diseases.

Even after plants are harvested, insects can cause further losses by:

- Feeding on stored products.
- Contaminating raw or processed agricultural commodities.

Animals. Important injury to livestock and pets occurs when insects:

- Chew skin, fur, or feathers.
- Suck blood.
- Invade body tissues.
- Annoy or irritate.
- Transmit diseases.

Humans. Insects pose health risks to humans by transmitting disease. Insects are also considered pests if they interfere with our daily activities or offend our aesthetic values.

Identifying Insect Pests

An effective IPM program begins with identifying the problem. This means knowing your crop or livestock pests and scouting fields.

Know key pests. There's no substitute for knowing the enemies that crops and livestock face. Certain insect problems are predictable for each crop and livestock species in your area. These insects are called "key pests." Learning about their life cycles, identification, injury symptoms, and management is the foundation of your IPM program. This knowledge will also allow you to recognize unusual situations that require further attention.

Scout fields. Because insects can reproduce so rapidly, it is essential to detect insect infestations promptly. Know which insect problem you're facing and how severe it is or may become. You can only do this by scouting your fields on a regular basis. Some insects can be monitored by using pheromones in traps, for example, black cutworms.

Control Measures for Insects

Most of the tactics for managing insects require planning. The goal is to avoid or minimize insect outbreaks. Unfortunately, even with planning, some insect outbreaks may require short-term rescue tactics, such as early harvest or insecticides. But these short-term tactics also require planning because, with insects, timing is so important.

Cultural control methods

Sanitation removes existing infestations or the resources needed for a pest buildup. Examples: cleaning grain bins and the surrounding area of infested grain and grain debris; removing manure breeding sites for filth flies.

Tillage directly affects survival of insects that live in soil or crop debris. Indirectly it influences how attractive and suitable the environment is

to insects. Example: reduced tillage systems suffer more frequent and severe damage from black cutworms.

Resistant varieties are a low-cost, highly effective control that has minimal impact on the environment. Some varieties may prevent a pest from becoming established or may kill it (Example: young corn contains a chemical that prohibits the European corn borer from feeding). Some varieties may be less attractive than others to insects (Example: slower-growing varieties suffer less damage from first-generation European corn borers if they are near faster-growing varieties). Some varieties may tolerate injury and still yield well (Example: differences among varieties in strength of corn stalks or ear shanks can affect losses from second- and third-generation European corn borers).

Crop rotation makes it harder for a pest to know when or where a crop will appear. This strategy is very effective against pests that overwinter as eggs or larvae and against pests that have limited ability to disperse (Example: crop rotation is extremely effective against corn rootworms that overwinter as eggs). Crop rotation is useless against insects that disperse readily during the growing season, such as potato leafhoppers, armyworms, or European corn borers.

Biological control methods

Protecting natural enemies of insect pests by avoiding unnecessary insecticide use, targeting insecticides, and using selective insecticides. Example: thiodicarb (Larvin) is effective against various defoliating caterpillars of soybean but does not affect many of the caterpillar's natural enemies.

Using natural enemies or their products the same way you would use an insecticide. Example: the bacteria *Bacillus thuringiensis* produces a toxin which in one strain is effective only against caterpillars, while another strain is effective only against mosquitoes and black flies.

Releasing natural enemies from other areas. This is a tactic that is used by entomologists (scientists who study insects). Most of the insect pests in this country were introduced from other areas, but not always with their natural enemies. Entomologists search the areas of origin for natural enemies that can be released successfully in the U.S. and that can be controlled here. Example: natural enemies have been introduced into Minnesota to help control alfalfa weevil and European corn borer.

Mechanical and physical control methods

These methods, which include cold or heat to kill insects or slow down activity, screens to keep insects out, and bug zappers that attract and kill insects, are not effective for crop pests; however they are widely used against insect pests of livestock and stored grain and for nuisance pests around the home.

Chemical control

Insecticides are the main type of chemical used in insect control. Other chemical control measures include use of pheromones, insect growth regulators, and sterilants. These are sometimes thought of as biological controls, because they are related to the natural biology of the insect.

The advantages and disadvantages of insecticides were discussed in the first part of this section on Integrated Pest Management. Despite their drawbacks, insecticides are often the only option available when insect outbreaks threaten economic losses. Remember, though, that scouting and using economic thresholds will help avoid unnecessary yield loss and unnecessary insecticide use.

Information about specific insecticides and their use can be found in these University of Minnesota Extension Service publications: AG-BU-0500 Insecticide Suggestions to Control Insect Pests of Field Crops; and AG-BU-0499 Insecticides.

Managing Plant Diseases

A plant disease is an abnormal condition that affects the structure or function of a plant. A diseased plant may be shorter or have fewer leaves than normal; it may not produce flowers or fruit; it may wilt and die prematurely. Unlike an injury, which occurs instantly, a disease is a process. It is caused by a disease-producing agent and is harmful in some way, even though the harm may not always be detected immediately.

The three steps in managing plant diseases are: 1) detecting symptoms of the disease, 2) identifying the cause of the disease, and 3) using appropriate control measures.

Symptoms of Plant Diseases

The first step in controlling plant disease is to examine your crops for symptoms of disease. There are five types of plant disease symptoms:

Necrosis is the death of cells or entire portions of the plant. Necrotic tissue is usually discolored, often appearing brown or black. There may be extensive decay (Examples: dry rots, soft rots, brown rots, white rots), or only small areas may be affected (Examples: leaf spots, fruit spots, blotches, scabs, stripes, streaks).

Overdeveloped tissue includes galls, clubroot, leaf curls, and warts.

Underdeveloped tissue includes stunting, dwarfing, and some malformations.

Discoloration of tissue, is usually due to a lack of chlorophyll, unless it is the discoloring that results from necrosis. The usual symptom is yellowing (chlorosis) of normally green tissue, but sometimes there may be a red discoloration. Chlorosis is an early symptom of many diseases.

Wilt is the loss of rigidity and drooping of plant parts. Wilt may be due to low soil moisture, necrosis of the roots or stems, or a disease agent plugging the plant's water transport tissue.

Plant diseases are often classified according to symptoms, for example: blights, mildews, rots, or mosaics.

Identifying Plant Diseases

The symptoms described above can be caused by several different diseases. The next step is to identify the cause of the symptoms. There are two parts to this process: 1) determining if the disease is parasitic or nonparasitic, and 2) identifying the specific cause.

Parasitic and nonparasitic diseases

Generally there are two types of disease: parasitic diseases caused by pathogens (disease-causing agents), such as viruses, and nonparasitic diseases caused by something in the environment, such as lack of water.

Ask the following questions to help decide whether your crop's disease is parasitic or nonparasitic:

How is the disease distributed in your fields? Is there a pattern? Are all of the plants in the field affected? Are the affected plants distributed in spots or in a particular row or rows? Definite patterns, such as along the edges of a field, along roadways or fences, or in low spots, suggest that climate, soil factors, or toxic chemicals are the cause, but pathogens (disease-causing organisms) should not be ruled out. If all of the plants in a field are affected, it's likely that the problem is environmental (for example, an excess or lack of soil nutrients, adverse weather, toxic chemicals, or poor cultural practices) because pathogens rarely affect 100 percent of the host plant at one time. If affected plants are limited to a particular row, this might indicate errors in cultivating, fertilizing, or applying pesticides.

How did the disease develop? Parasitic diseases usually spread slowly. If a condition starts at one point and then spreads slowly, it is probably due to a pathogen. If a disease appears overnight, it is probably due to an environmental factor, for example, hail or lightning.

Is there a common disease problem for the crop or area? It's easier to identify a disease if you are familiar with the kinds of problems that are likely to affect your crops.

Have you thoroughly examined all symptoms? If you diagnose a disease early, you will get the most benefit from a control treatment. Be sure the plant is really diseased. Always compare a plant you think is diseased with a normal one. Sometimes normal structures and characteristics are mistaken for disease symptoms. The symptoms should be well defined—don't rely only on symptoms that appear during the early stage of a disease. On the other hand, don't rely on a plant that has deteriorated so badly that characteristic symptoms cannot be identified.

Always examine the entire plant. Some aboveground symptoms, especially chlorosis and wilting, are often due to root damage. Always examine the roots of a diseased plant if you are at all unsure of the cause. It can also be helpful to cut into or through portions of diseased plants. For example, vascular wilts may cause a browning inside the stem; you can often see this discoloration if you cut through portions of the stem.

A small hand lens, a pocket knife, and a shovel are important tools for plant disease diagnosis.

Are there signs that indicate the cause? Such signs include: fungus spores, nematodes or eggs, and bacterial ooze. Signs are harder to see than symptoms. You may need a microscope or magnifying glass to see them. More training is needed to find and identify signs than to observe symptoms.

Identifying the specific cause

Once you have a general idea of whether the disease is parasitic or nonparasitic, you can focus on the specific cause. If you are unsure of the cause, ask for help from your county extension agent. If necessary, the agent will send a disease specimen for positive identification to the Plant Disease Clinic at the University of Minnesota.

Environmental factors that may cause plant disease include nutrient deficiency, extreme cold or heat, toxic chemicals (air pollutants, weed killers, too much fertilizer), mechanical damage, lack of water, and genetic abnormalities. In trying to identify the cause of a plant disease, consider whether you have used any cultural practices that might have caused the disease, such as cultivation, fertilization, irrigation, or pesticide application.

The most common causes of parasitic diseases are fungi, bacteria, viruses, and nematodes. They are living organisms that live and feed on plants.

Fungi are plants that cannot make their own food because they lack the chlorophyll found in seed-producing plants. People commonly call fungi molds. Fungi are responsible for several crop diseases, including tan spot on wheat and late blight on potatoes. There are more than 100,000 kinds of fungi. Not all are harmful, and many are helpful. Most are microscopic, but some, like mushrooms, produce large reproductive structures. Most fungi reproduce by spores, which vary greatly in size and shape.

Bacteria are very small one-celled plants that reproduce by dividing in half. This can lead to rapid buildup of a population. Under ideal conditions, a single cell could produce billions of offspring in 24 hours. Bacterial diseases include basal glume blotch on wheat and common blight on beans.

Viruses are so small that they cannot be seen with an ordinary microscope. They can be transmitted by insects (usually aphids and leafhoppers); by rubbing the leaves of healthy plants with juice from diseased plants; by propagating plants from infected cuttings, bulbs, or roots; by nematodes and soil fungi; and in pollen. An example of a plant virus is the tobacco mosaic virus.

Nematodes are small wormlike organisms that can be seen with a microscope. They reproduce by laying eggs. Their rate of reproduction depends largely on soil temperature, so nematodes are usually more of a problem in warmer areas. Nematodes may develop and feed inside or outside a plant. A complete life cycle involves an egg, four larval states, and an adult. The larvae usually look like the adults, but are smaller. Most nematodes feed on the roots and lower stems of plants, but a few attack the leaves and flowers. They usually do not kill plants, but they do reduce growth and affect plant health.

The life cycle of parasites

Environmental conditions, especially temperature and moisture, greatly influence the life cycle of parasites. These conditions also affect the plant's ability to fight off a disease.

The first step in a parasitic disease cycle occurs when a fungus spore, nematode egg, bacterial cell, or virus particle arrives at a part of the plant where infection can occur. This step is called *inoculation*. If environmental conditions are favorable, the parasite will begin to develop. This step is called *incubation*. This is the stage when control is most effective. The next stage occurs when the parasite gets into the plant; this step is called *infection*. When the plant responds to the invasion of the pathogen in some way, it is considered *diseased*.

Control Measures for Plant Diseases

The main goal is to prevent plant diseases from occurring. Once a plant is infected, it is usually too late to prevent its death or to prevent serious reductions in crop yields. When only part of a crop is diseased, eradication may prevent further spread. Eradication can be done with cultural as well as chemical methods. Always weigh the cost carefully before making treatment decisions. Chemical treatment, such as with fungicides, should be regarded as a last resort.

Cultural control methods

- Choose planting sites and dates of planting.
- Use resistant varieties.
- Use sanitation, crop rotation, and primordium tip-culture techniques following fields.
- Use proper soil, water, pH, and fertility applications to assure maximum plant vigor.
- Remove infected plants or plant parts.

Biological control methods

- Use organisms that are antagonistic to the disease, such as hyperparasites or microorganisms.
- Use cross-protection techniques for viruses.

Mechanical and physical control methods

- Treat soil or plant parts with heat.
- Use proper storage or curing methods for plants and plant products.

Legal control methods

- Obey quarantine regulations with inspections to prevent pathogens from being introduced via plants or equipment into areas where they do not already exist.
- Certified disease-free seed and nursery stock.

Chemical control methods

- Use chemicals to protect the host plant before it is infected.
- Use pesticides to eradicate the pathogen after it has infected the host plant.
- Use the correct chemical for the pest: fungicides for fungi; antibiotics for bacteria; viricides for viruses; nematicides for nematodes.

Managing Weeds

What Is a Weed?

A weed is simply a plant out of place. Weeds are a problem because their presence can mean reduced crop yields and quality, less efficient land use, and diminished enjoyment of turf, ornamental plants, and outdoor recreation areas.

Certain plants have legally been declared noxious weeds. In Minnesota, state regulations list marijuana, poison ivy, bull thistle, perennial sow thistle, musk thistle, plumeless thistle, Canada thistle, field bindweed, leafy spurge, and purple loosestrife as “noxious weeds.” Noxious weeds must be cut or controlled so that they do not produce seeds. Some local governments require control of additional weeds.

The weeds that are the most serious problems are those that resemble the crop in physical characteristics, growth habits, and requirements for soil, water, nutrient, and light. Broadleaf weeds are often most difficult to control in broadleaf crops, and grass weeds in grass crops. Another problem with controlling weeds is that some production methods, especially cultivation, favor some weeds.

Most weeds have common names like cocklebur or crabgrass. The trouble with common names is that people in different places may use different names for the same plant. Herbicide labels and publications that give weed control information generally use standardized common names. You need to know the standardized common name of a weed so you can choose the proper control method.

How Weeds Grow and Reproduce

To control weeds, you need to know something about how they grow and reproduce.

Life cycles

Weeds can be classified as annuals, biennials, and perennials.

Annuals are plants with a one-year life cycle. They grow from seed, mature, and produce seed for the next generation in one year or less.

Summer annuals are plants that result from seeds that germinate in the spring, produce seed, and die before winter each year. *Winter annuals* are plants that grow from seeds that germinate in the fall, overwinter, produce seeds in the spring and die before summer each year.

Summer Annuals:

- Crabgrass
- Foxtails
- Cocklebur
- Pig weed
- Lambsquarter
- Kochia
- Black nightshade
- Velvet leaf
- Common ragweed
- Wild oat

Winter Annuals:

- Field pennycress
- Shepherd's purse
- Annual bluegrass
- Peppergrass

Biennials:

- Burdock
- Musk thistle
- Bull thistle

Perennials:

- Quackgrass
- Canada thistle
- Field bindweed
- Yellow nutsedge
- Sowthistle

Biennials require two years to complete their life cycle. They grow from seed that germinates in the spring. They develop heavy roots and compact rosettes or clusters of leaves the first summer. Biennials remain dormant through the winter; in the second summer they mature, produce seed, and die before winter.

Perennials are plants that live more than two years—sometimes indefinitely. They may grow from seed, but many produce tubers, bulbs, rhizomes (belowground stems), and stolons (aboveground stems). The aboveground parts of these plants may die back each winter, but the plants develop new aboveground parts each spring. *Simple perennials* produce seeds each year as their normal means of reproduction; in some instances, following mechanical injury during cultivation, root pieces may produce new plants (Examples: dandelions and plantain). *Creeping perennials* produce seeds but also produce rhizomes and stolons.

Seeds

The most important part of weed control is preventing the production of seeds. This is true whether you are trying to control annuals, biennials, or perennials. Weed seeds have certain characteristics which make them very difficult to control:

Large numbers. Weed species often produce enormous numbers of seeds. For example, a single pigweed plant may produce 100,000 seeds.

Tolerant of extreme conditions. Weed seeds are notably tolerant of extremes in temperature, wet and dry conditions, and variations in oxygen supply.

Long-lived. Weed seeds may remain alive in the soil for a great many years. Only a small percentage germinate in any single year; the remaining seeds stay dormant and germinate in future years, when temperature and oxygen conditions are more favorable.

Easily spread. Weed seeds are effectively spread by wind, water, animals (including humans), or machinery, and in crop seed, feed grain, hay, straw, and manure.

Control Methods for Weeds

The most effective ways to control weeds are through cultural and chemical means. Biological control methods, using natural enemies of weeds such as insects or diseases, have not been successful thus far in Minnesota. But this method offers some potential for the future. Researchers continue to search for natural enemies and attempt to introduce them into areas where a particular weed is prevalent.

A weed control program should be planned well in advance of the growing season. Your plan should be based on a thorough knowledge of weed problems, soil, soil characteristics, future cropping plans, and all available methods of control. As crop production practices change—for example, tillage—so do weed problems; a good weed control program must be flexible. Control of a particular weed should be just one part of a total weed control program.

Annuals and biennials depend exclusively on seed for reproduction and survival. Therefore, an effective way to control them is by destroying the top of the plant—by mowing, tillage, or herbicides. It is important to

destroy the growing point to prevent further growth and seed production. For this reason, it is harder to control grasses than broadleaves because the growing point in grasses is often at or below ground level. Annuals are rarely able to resprout from their roots, but some biennials (such as musk and plumeless thistles) can regrow from roots.

Perennials are more difficult to control by simply destroying the top growth. It is more effective to destroy the underground parts of the plant, either through tillage or with herbicides. Perennials have specialized underground parts that help the plant to survive and reproduce. Even with simple perennials (such as dandelions), which reproduce only by seed, energy for regrowth is normally stored in the roots. Destroying the top growth on a one-time basis will not kill the plant, unless it is done in the seedling stage before the underground parts have developed. Destroying the top growth can only be effective if it is done repeatedly.

Cultural control methods

Cultural control of weeds—hand weeding, plowing, harrowing, etc.—has been practiced for centuries. Many of the methods of weed control used today have changed very little over the years. They include:

Clean seed. It is often easier to prevent weeds from being introduced than it is to control them. Use only tested and tagged seed; certified seed ensures high quality seed free of noxious weeds.

Clean feed. Weed seeds in feed grains and forages survive and germinate after passing through farm animals; manure spread on fields may therefore be spreading weed seeds. Screenings containing weed seeds are sometimes used in mixed feeds; they must be finely ground or heated or else the seeds will remain alive.

Tillage. Burial of weeds can be effective for small annuals and biennials, but will not control most perennials if it is done beyond the seedling stage, unless done repeatedly. For perennials, it is more effective to destroy underground parts, using sweeps, knives, harrows, rotary hoes, and other shallow cultivation equipment. This type of control is most effective in dry soils where roots have little chance of becoming established.

One problem with tillage is that it brings weed seeds up near the soil surface, resulting in germination of a new population of weeds. These can be controlled, especially if they are annuals, by cultivating a second time. Plant the crop immediately after the last cultivation to allow sufficient growth before weeds again become a problem.

Mowing is effective only for tall-growing weeds. Certain tall perennials can be mowed to the point where regrowth is no longer possible, but this requires repeated and frequent mowing.

Crop competition means growing your crops so well that they crowd out the weeds. To make sure your crops compete effectively with weeds, always select the best variety and use the best crop production methods.

Rotating crops with different life histories or growth habits can control weeds associated with a particular crop. For example, many summer annual weeds associated with corn will not do well under the cultural practices of fall-planted small grains.

Fallowing fields, or allowing intervals for chemical treatments, may partially solve some special weed problems.

Companion crops, usually annuals that germinate quickly and grow rapidly, can be planted with a perennial crop to compete with weeds and allow the major crop to become established. The companion (or nurse) crop is then removed to allow the perennial crop to take over. Example: oats are often used as a companion crop in Minnesota to aid in establishing a crop of alfalfa.

Herbicides

Chemical control through the use of herbicides is the most common method of weed control in agriculture. Herbicides work in different ways. Here are the most common types of herbicides:

Selective herbicides are herbicides that are more toxic to some kinds of plants than to others. Selectivity depends on such things as plant age, rate of growth, and plant form.

Nonselective herbicides are toxic to all plants. Some nonselective herbicides can be made selective to certain plants by varying the dosage, directing the spray to a specific site, or choosing spray additives such as wetting agents. Selective herbicides can be made nonselective by manipulating the same factors (for example, an increase in the dosage can kill more types of plants).

Translocated herbicides can be absorbed by leaves, stems, or roots and moved throughout the plant. Root absorption and translocation take place in water-conducting tissues; leaf or stem absorption and translocation take place mainly in food-conducting tissues.

Contact herbicides are toxic to living cells upon contact. They do not translocate in a plant. Contact herbicides destroy only the aboveground parts of plants and are only effective against annual weeds.

Soil sterilant herbicides are nonselective herbicides that kill all plants and prevent weeds from becoming reestablished for a relatively long time.

Herbicides can also be classified according to when they are applied: before planting (preplant), before seedlings appear (preemergence), and after seedlings appear (postemergence).

Factors affecting herbicides

Soil type

- Organic matter in soils limits herbicide activity. Soils with a high organic matter content require higher rates of herbicides. Most herbicide labels have charts showing the rates to be used on soils with varying levels of organic matter.
- Soil texture may also affect herbicide activity. Fine soils (silts and clays) have more surface area than coarse soils and thus need higher herbicide rates.
- Soil acidity can influence some herbicides. Chemicals such as atrazine and metribuzin (Sencor or Lexone) are more active in soils that have a higher pH.

Environmental conditions

- Soil moisture allows herbicides to work most effectively. If the soil is too dry, the herbicide may evaporate. If it is too wet, the herbicide may not make contact with soil particles. Warm, moist soil may increase microbial and chemical activity, causing herbicides to disappear. But dry soils may prevent chemical and microbial activity, preventing herbicides from degrading and causing the herbicide to remain in the soil the following year.
- Rainfall causes soluble herbicides to leach downward through the soil. This may be desirable with relatively insoluble herbicides but with more soluble herbicides it may cause crop injury. Heavy rainfall may result in poor weed control or possible crop injury, depending on the solubility of the herbicide. With preemergence herbicides, rainfall is needed to carry the chemical into the soil where the weed seeds are germinating and to provide moisture to help the weed seeds germinate so that they can absorb lethal amounts of herbicide. With postemergence applications, rainfall may wash herbicides from leaf surfaces, resulting in poor weed control.
- Humidity affects postemergence herbicide penetration and absorption. High relative humidity indicates favorable soil moisture conditions for rapid plant growth, a time when plants are very susceptible to herbicides.
- Dew on the weeds or crop when postemergence herbicides are applied may increase or decrease the activity of some herbicides, depending on how quickly the chemical is absorbed by plants and how the chemical kills plants. The presence of dew can also increase crop injury with some postemergence herbicides.
- Temperature affects the rate of plant growth and plant susceptibility to herbicides. Some herbicides evaporate quickly at high temperatures.
- Sunlight may destroy some herbicides if they are left on the soil surface for long periods.

Differences among weeds

- Perennials are controlled more effectively with translocated herbicides because these chemicals move into all parts of the plants, whereas contact herbicides kill only the aboveground parts.
- Type of weeds determines which herbicides may provide control. Some herbicides are strictly for use with broadleaf (dicotyledon) weeds. Some are strictly for grass (monocotyledon). A few herbicides can be used with both types of plants.
- Plant species may respond to some herbicides differently. Moreover, within a single species there may be races of the weed that respond differently.
- Growth rates. The age of the plant and the rate of growth also affect how weeds respond to herbicides.

Preventing herbicide carryover

Some herbicides remain in the soil a long time, causing crop injury in the following year's crop. Herbicide carryover is more likely to occur with unusually low rainfall because dry soils limit the chemical and microbial activity needed to degrade herbicides.

To keep herbicide carryover in soil to a minimum, follow these guidelines:

- Apply the lowest rate practical.
- Apply uniformly.
- Avoid double coverage: shut off the applicator when turning.
- Select crop sequences that are tolerant to the herbicide used on the previous crop.
- Rotate herbicides whether the same crop is grown continuously or different crops are grown in rotation.
- Spot treat when using high rates of herbicide.

More details on herbicides and other weed control methods can be found in the University of Minnesota Extension Service Bulletin AG-BU-3157 Cultural and Chemical Weed Control in Field Crops. This bulletin can help you plan an effective and economical weed control program.

Managing Vertebrate Pests

When Is a Vertebrate a Pest?

All vertebrate animals have a jointed spinal column (vertebrae). These "higher" animals include fish, amphibians, reptiles, birds, and mammals. What may be a pest under some circumstances may be highly desirable under others. Your first job in controlling vertebrate pests is to determine if they are actually causing damage.

Fish of certain species may be considered pests by some because they are not useful for sport or for food or because they are harmful to more desirable species. Some fish may be a human health hazard because they serve as intermediate hosts for parasites of humans.

Reptiles and amphibians include snakes, lizards, turtles, frogs, toads, and salamanders. These animals cause more of a psychological problem than an economic one. But snakes and turtles in fish hatcheries or waterfowl production areas can cause some economic problems. Poisonous snakes may be a problem, too, but there are only two poisonous species in Minnesota, both restricted to the southeast corner of the state.

Birds can cause various kinds of damage: structural damage by woodpeckers; killing of fish, livestock, poultry, or game species; and destruction of fruit, nut, grain, timber, and vegetable crops. Birds can also be a health hazard to animals and humans because they may be hosts for disease organisms.

Mammals, such as pocket gophers, moles, and rats, can also cause a variety of damage. Livestock may be killed by mammals. Mammals also do significant damage to fruit, vegetable, nut, grain, range, and tree crops. They may interfere with water-retaining structures, causing flooding. They damage such things as lawns, clothing, furniture, and buildings by gnawing and burrowing. They transmit many diseases to livestock and humans, including rabies, plague, typhus, food poisoning, leptospirosis, and tularemia.

Managing pocket gophers

Pocket gopher numbers may be reduced by mechanical controls, such as traps, and natural controls, including natural enemies, starvation, and disease. The most effective way to control pocket gophers is with poison bait (strychnine alkaloid coated grain). Strychnine is toxic to all animals and must be handled and applied according to label instructions. ALL applications must be belowground. Clean up all spilled bait.

Except during breeding season, gophers live alone in a system of burrows. One adult may build as many as 100 mounds a year, moving as much as 2¼ tons of soil to the surface. Feeding burrows may be only 6 inches below the surface while food storage and living chambers may be 5 to 6 feet deep.

On small acreage (10 acres or less), hand application of poison bait during the fall is usually effective. For added control, combine it with a fall trapping program. Trapping in the spring following a fall baiting program can also be effective. Special pocket gopher traps are available at most nurseries, farm supply, and large hardware stores.

On areas larger than 20 acres, the most practical means of control is machine baiting with a burrow builder. Fall and spring applications give the greatest control. The soil must be moist enough to let the torpedo tube pass through easily and to hold a neat burrow shape when compressed. A depth of about 10 inches is desirable, but the burrow depth is less important than forming a neat tunnel. Completely enclose the field to be protected by parallel rows of artificial burrows spaced 25 to 40 feet apart—wider spacing in the spring, narrower in the fall. If bait is applied properly, you should attain 85 to 90 percent control within three weeks. Reapplication may be needed in two to four years.

Some counties own burrow building machines which are available to pesticide applicators. Check with your county extension educator, Soil Conservation Service, or Soil and Water Conservation District.

Identifying the Problem

As with other IPM programs, the first step in control is to detect and identify the problem.

Recognize damage patterns and the species of animal responsible. Look for the following evidence:

- **Birds:** peck marks, tracks, feathers, droppings, location of damage, evidence that items have been carried away.
- **Mammals:** tracks, droppings, toothmarks, diggings, burrows, hair, scent, type of damage.

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

Selecting Control Tactics

Choose control measures that are effective, selective, humane, and cause the least possible environmental damage, such as traps, sound, or barriers.

Know the local, state, and federal regulations that apply. It is especially important to know which animals are protected by the federal and state government. Protected species include the gray wolf, bald eagle, and peregrine falcon. Two mammals considered by some as pests are the eastern spotted skunk and the woodland vole. These are classified as special concern because of their low population but are not legally protected. See Part 5—Protecting the Environment for more information on regulations protecting wildlife.

Summary

Integrated Pest Management (IPM) is a systematic plan which brings together different pest control tactics into one program. It reduces the emphasis on pesticides by including cultural, biological, and mechanical controls.

To carry out an IPM program, you need to scout and monitor your fields, recognize abnormal conditions and identify their causes, understand the different control methods available, and determine the economic costs and benefits. A good IPM program requires planning and evaluation.