CHAPTER 1

INTEGRATED PEST MANAGEMENT

LEARNING OBJECTIVES

After completely studying this chapter, you should:

- Be able to define integrated pest management.
- Understand the importance of an economic threshold.
- Know the basic principles of field scouting.
- Know the three ways that cultural control methods work.
- Be able to define and give examples of a natural enemy.
- Understand the various types of pesticides.
- Understand the importance of preharvest interval, residues, reentry interval, phytotoxicity, and pesticide resistance.

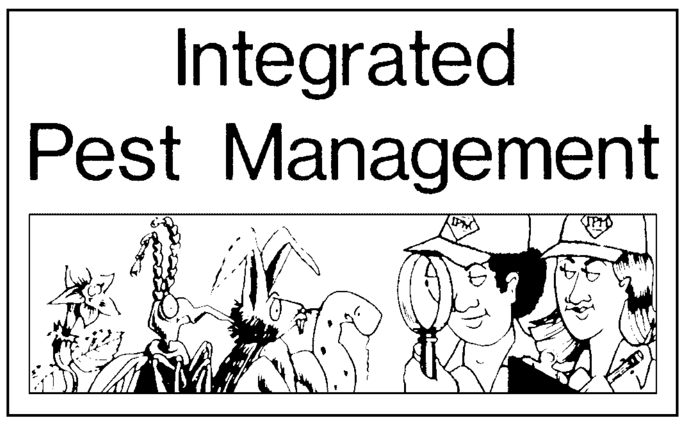
Vegetables are vulnerable to attack by pests. Pest damage can range from slight damage that has no effect on the value of the harvested product to severe damage that kills plants, significantly reduces crop yield, or reduces the crop's market value. Vegetable pests include insects and mites, weeds, diseases, and nematodes.

Effective management of pests is based on thorough consideration of ecological and economic factors. The pest, its biology, and the type of damage it causes are some of the factors that determine which control strategies and methods, if any, should be used. Pest management decisions largely determine the kind and amount of pesticides used.

Pest management decisions represent a compromise between the value of the product, the extent of the pest damage, the relative effectiveness and cost of the control measures, and the impact on the environment.

INTEGRATED PEST MANAGEMENT (IPM)

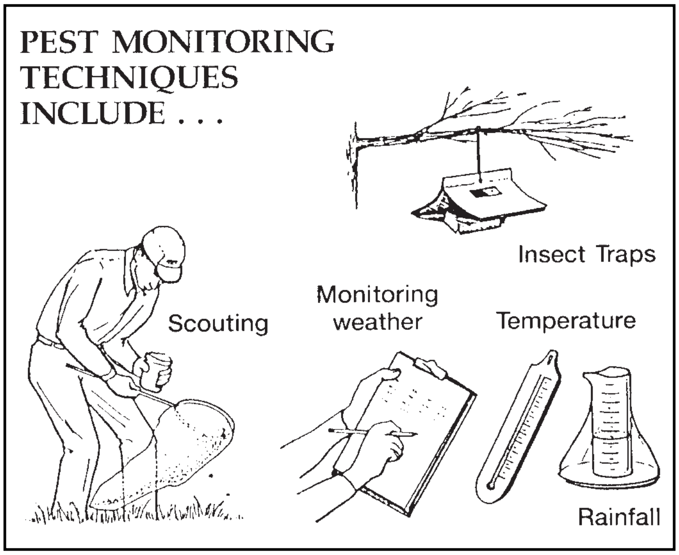
The goal of IPM is to use all appropriate tools and tactics to keep pest populations below economically damaging levels and to avoid adverse effects to humans, wildlife, and the environment. These tools include genetic resistance and cultural, biological, and chemical control methods. Management decisions are based on information gathered about the pest problem and the crop; then a combination of control measures that best suits the problem is used.



What are these IPM tools and how are they used?

FIELD SCOUTING, MONITORING

Field scouting is an important part of any IPM program because it helps define the pest problems. Correct identification and location of each pest in a crop are necessary for a successful pest management program. Regularly scouting fields can reveal: which pests are present, the growth stage of the pests and the growth stage of the crop; the location of the pests in the crop; whether the insect pests are healthy or diseased; the pest population and whether it is increasing or decreasing; and the crop condition. A scouting program should include accurately written records of field locations, field conditions, previous pest infestations, and control measures. With this information, you can determine what control measures are appropriate.



Remember the following basic principles when scouting:

- Take samples from several areas of the field.
- Select sample sites at random unless field conditions suggest uneven pest distribution.
- DO NOT sample in border rows or field edges unless indicated to do so for a particular pest.

Insect pests can be monitored in several ways. The most common methods are actually counting the number of insects present or estimating the amount of insect damage. Insect counts usually are expressed as the number of insects per plant or plant part (e.g., number of insects per leaf). Insect crop damage is often expressed as percentage of the plant damaged (e.g., percent leaf defoliation). Other insect monitoring methods include collecting insects with a sweep net, shaking crop foliage and counting dislodged insects, and trapping insects. Disease monitoring can be accomplished through scouting fields weekly and examining foliage for early disease symptoms. Also, monitoring the weather can indicate when conditions are favorable for disease development. Pest alerts and newsletters provided by MSUE county agents and other MSU personnel indicate pest pressure and outbreaks in the region and state.

ECONOMIC THRESHOLDS

An **economic threshold** is defined as the pest density at which action must be taken to prevent the pest population from increasing and causing economic damage. Economic thresholds are constantly changing and vary between fields, crop varieties, and crop growth stages. Economic thresholds are a function of crop value and cost of control. In general, a high-value crop will have a lower economic threshold; less pest damage will be accepted and control measures must be implemented sooner. If the control measures are expensive or the vale of the crop is low, the economic threshold is usually high. High control costs means it takes more crop loss to justify the control action.

Economic thresholds are often referred to as **action thresholds**. When the pest population reaches the threshold, action is taken to reduce the population. For insects, an economic or action threshold is typically expressed as the number of insects per plant or per leaf or the amount of crop damage.

CONTROL STRATEGIES

CULTURAL CONTROL

Cultural control uses farming practices to reduce pest populations by implementing a practice such as tillage or crop rotation at the correct time to kill or reduce pest numbers or slow pest development. Like all other control strategies, cultural control requires an understanding of the pest and the crop. Cultural control measures are usually applied at the weakest stage of the pest's life cycle and are generally preventive actions rather than curative actions.

Cultural control methods work in three ways:

1. Prevent the pest from colonizing the crop or commodity.
2. Create adverse conditions that reduce survival of the pest.
3. Reduce the impact of pest injury.

PREVENTING COLONIZATION

Control measures that prevent colonization physically exclude the pest, reduce pest populations, prevent the pest from finding the crop, or disrupt the timing between the pest and the crop.

A. Trap crop—planting a small area with a preferred host to attract the pest away from the crop. Once in the trap crop, the pest can be destroyed or controlled. For example, trap crops can help control striped cucumber beetles. The beetles are attracted to the oldest, most mature crop in an area. An early planting of pumpkins or cucumbers attracts early-season striped cucumber beetles, concentrating the population and preventing movement to the primary crop.

B. Physical barriers—separating a pest and host with an object such as a wall or a ditch to stop the pest from infesting—for example, covering the soil with black plastic to control weeds.

C. Crop rotation—a cycle in which different crops are planted in a field every year; the longer the rotation between crops susceptible to the same pests, the better the pest control. A crop rotation system helps control pests such as tomato diseases. Tomatoes should not be rotated with peppers, eggplant, or any cucurbits (pumpkins, zucchini, winter squash, cucumber, watermelon or muskmelon).

D. Delayed planting (timing)—changing the planting date so that the host is not available when the pest is present. Example: delaying the planting date of onions until after peak flight of onion maggot adults removes egg-laying sites and helps control onion maggots.

E. Cover crops—utilizing plant competition by planting a secondary crop to prevent weeds from becoming established. Example: using fall-planted rye as a living mulch for pumpkins. The rye is killed before seeding pumpkins and the rye residues suppress weeds.

Creating adverse pest conditions in the crop

Pests require specific living conditions. Cultural control methods can disrupt ideal pest conditions and decrease pest pressure. Adverse pest conditions can be created by destroying the host plant after harvest, physically moving the soil, changing water management practices and spatial arrangement, and using the plant's natural defense mechanisms.

A. Destroy crop residue, alternate hosts, and volunteer crops—eliminating the pest or pest habitat found in crop residue, or destroying alternate hosts of the pest found near or in the crop – for example, destroying corn debris after harvest to reduce overwintering European corn borers.

Pests, particularly plant pathogens, can survive in a field on volunteer crops and alternate hosts. The survival of these pathogens provides a source of **inoculum**. For example, aster yellows and its vector survive on volunteer crops and weeds. Both the phytoplasma and the insect population can build in the primary crop, increasing the likelihood of infection.

B. Tillage—physically moving the soil around the crop. Tillage can destroy an insect and uproot and cover weeds. All of these factors can reduce pest populations.

C. Water management—Water is needed for healthy plant growth but avoid water-related conditions that promote pest problems such as disease spread. For example, *Phytophthora* is a water mold that is favored by saturated soil conditions. Using raised beds for squash and cucumbers helps prevent loss from *Phytophthora*.

D. Spatial arrangement (seeding rate and row spacing)—changing the spatial arrangement of the crop to reduce pest populations. For instance, when plant spacing and row width are reduced, plants can outcompete weeds for light, water, and nutrients. On the other hand, close plant spacing may provide an environment favorable for disease development, such as white mold in snap beans.

E. Allelopathy—one plant species reducing competition from another plant species by releasing toxic chemical agents into the soil. Allelopathy has minimal potential in weed management. For example, in a conservation tillage system, leaving residues of some varieties of rye can reduce the number of weeds.

REDUCE PEST INJURY TO CROP

Cultural control also utilizes a plant's defense mechanisms to minimize pest damage. Planting pest-resistant crops, maintaining a healthy crop, timing harvest to reduce pest damage, and practicing pest-reducing storage techniques can reduce pest injury.

A. Host-plant resistance—the host plant's ability to tolerate pest pressure. Plants have defense mechanisms that allow them to either repel the pest or withstand the pest's damage.

B. Plant health—maintaining strong, healthy plants that are better equipped to out-compete weeds, fight disease, and withstand insect damage.

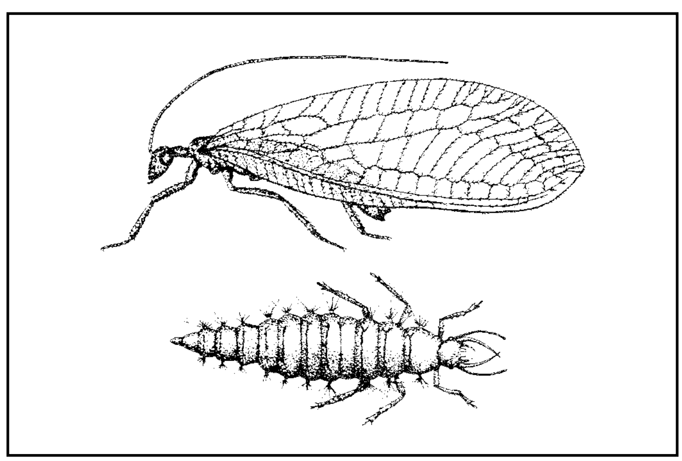
C. Harvest timing—changing the time when a crop is harvested to reduce pest impact on yield. For example, if a field is infested with *Phytophthora*, the vegetable crop should be harvested as soon as it is mature to decrease the time that the crop is exposed to the pathogen.

D. Storage practices—handling, curing, and storage practices to prevent the spread of disease during storage. For instance, controlled temperature and ventilation are essential to minimize losses in potatoes.

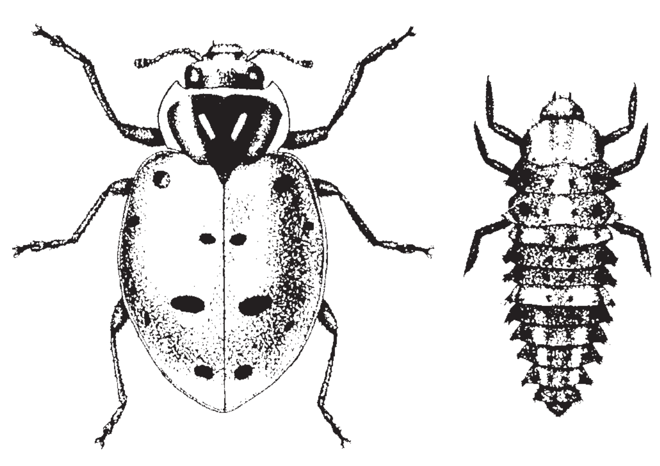
BIOLOGICAL CONTROL

Biological control is the use of living **organisms** to reduce a pest population. These beneficial organisms are referred to as natural enemies. Predators, parasitoids, and pathogens are the most common natural enemies.

- **Predators**—other organisms that eat the pest. Predators are usually not specific and will eat a variety of pests.

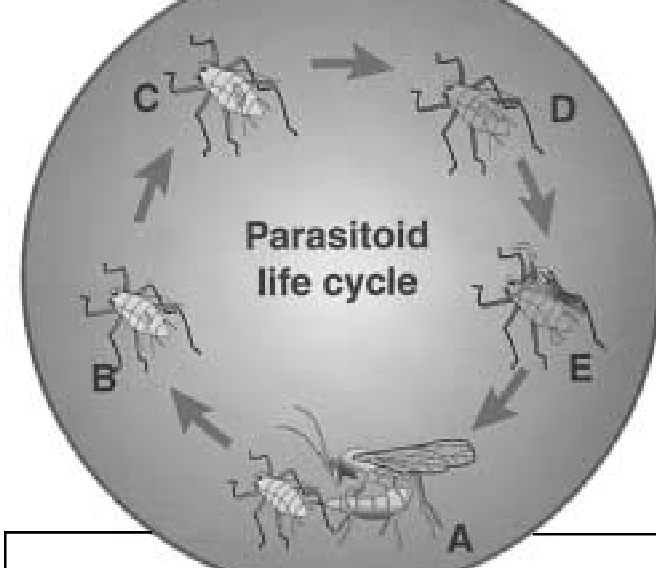


Green lacewing adult and insect eating larva.



Ladybird beetle adults and larvae consume large numbers of aphids and mites.

- **Parasitoids**—organisms that must live in or on another organism to complete their life cycle. A parasitoid is usually an insect that develops and feeds inside another insect. An adult parasitoid lays an egg in or on a host insect. When the parasitoid egg hatches, the parasitoid larva feeds on the host insect. Eventually, the developing parasitoid kills the host insect by eating it from the inside out. Parasitoids are usually host specific and include tiny wasps and flies.



A. Wasp lays egg in host (for example, an aphid).
B., C. As the host feeds and grows, so does the wasp larva.
D. Parasitoid kills then pupates within dead host.
E. An adult parasitoid emerges from the dead host.

Examples of insect biological control agents (natural enemies).

Natural Enemy	Pests Controlled
PREDATORS	
lady beetles	aphids, scale insects
green lacewings	aphids, mites, others
spined soldier bug	Colorado potato beetle, Mexican bean beetle
minute pirate bug	corn earworm eggs, mites
PARASITOIDS	
tachinid flies	beetles, caterpillars
ichneumonid wasps	caterpillars, leafrollers, weevils, others
braconid wasps	caterpillars, beetles, aphids
Trichogramma wasps	eggs of moths, such as European corn borer
PATHOGENS	
Bacillus thuringiensis	caterpillars, some beetle larvae, mosquito and blackfly larvae
nuclear polyhedrosis viruses (NPV)	caterpillars
Beauveria bassiana (fungus)	caterpillars, grasshoppers, aphids
Nosema (protozoan)	caterpillars, beetles, grasshoppers
Streptomyces griseoviridis strain K61 (Mycostop®) (fungus)	seed, root, and stem rot, and wilt caused by *Fusarium*, *Alternaria*, and *Phomopsis*
Trichoderma harzianum Rifai strain KRL-AG2 (PlantShield™) (fungus)	Plant pathogens such as *Pythium, Rhizoctonia, Fusarium, Botryis*, and powdery mildew.

■ **Pathogens**—disease-causing organisms such as bacteria, viruses, and fungi that infect and kill the pest. Environmental conditions such as high humidity or high pest abundance allow naturally occurring pathogens to multiply and cause disease outbreaks (epizootic), which reduce a pest population. Some insect pathogens are manipulated to control specific pests. For example, the soil bacterium *Bacillus thuringiensis* (commonly known as Bt) can kill a variety of insects, including caterpillars and mosquito and beetle larvae.

CHEMICAL CONTROL

Chemical control reduces a pest population through the application of pesticides. The decision to use a pesticide as part of an IPM program should be based on a scouting program, pest identification, economic thresholds, and the crop/pest life stages. When used properly, pesticides provide effective and reliable control of most pest species.

TYPES OF PESTICIDES

Pesticides used to control vegetable crop pests are applied either to the soil or to the plant foliage.

■ **Soil-applied pesticides**

Chemigation—applying a pesticide or fertilizer to the soil by injecting it into the irrigation system.

Insecticides—applied to prevent insect damage to the roots of corn and other crops. Insecticides can be applied by broadcast soil applications and soil incorporation before planting, applied in the seed furrow at planting, or broadcast before or after crop emergence.

Fungicides—applied to soil to prevent damage to the roots caused by soilborne fungi. Fungicides can be applied by broadcast soil application and soil incorporation before planning, applied in the seed furrow at planting, or broadcast before or after crop emergence.

Herbicides—applied to the soil surface and mixed into the soil before planting (**preplant incorporated**) or applied after planting but before crop emergence and not incorporated (**preemergence**).

Soil fumigants or nematicides—applied to the soil to control nematodes before planting.

■ Foliar-applied pesticides

Foliar applications are applied directly to crop leaves. They can be applied before damage occurs (**preventive**) or in response to damage (**curative**).

Insecticides—generally applied to control insects that are feeding above-ground on the crop.

Herbicides—applied to the weed foliage after the crop and weeds have emerged (**postemergence**).

Fungicides—applied to the crop before the disease appears to prevent disease (**protectant**) or to control disease after it appears (**eradicant**).

The following are special considerations to remember when using a pesticide to control your pest problem:

Preharvest interval—the minimum number of days needed between the last pesticide application and harvest. Preharvest intervals are established by the Environmental Protection Agency (EPA). The preharvest interval is based partly on how long it takes the pesticide to break down. Observing the preharvest interval reduces or eliminates pesticide residues on the commodity.

Residues—the pesticide that remains on the crop after an application. Ideally, a pesticide is present only long enough to kill the pest and then breaks down. Because many pesticides do not break down completely before harvest, for each pesticide registered for use on a food or feed crop, the EPA sets the amount of acceptable residue (**tolerance**) permitted on the harvested crop. The amount of residue relates to the preharvest interval and the pesticide application rate. Harvesting a crop during the preharvest interval or applying more pesticide than the label allows increases the risk of residues exceeding legal tolerance levels.

Reentry interval (REI)—the amount of time required after a pesticide application before a person can reenter a field without personal protective equipment (PPE). The reentry interval prevents unnecessary pesticide exposure. Only workers trained for early entry under the Worker Protection Standard (WPS) and wearing proper personal protection equipment may enter a treated area during the reentry interval. Refer to the Worker Protection Standard for the regulations on informing workers about pesticide applications.47

Phytotoxicity—when a pesticide damages the crop to which it is applied. Pesticide drift, excessive rates, mixing incompatible pesticides, adverse weather, using the wrong pesticide, and improper calibration of equipment can all cause phytotoxicity. Even using pesticides in accordance with the label can result in some phytotoxicity. Applying pesticides within recommended rates and following label instructions for mixing and applying help avoid this problem.

Pesticide resistance—the genetic ability of an organism to tolerate the toxic effects of a pesticide, such as malathion-resistant Indian mealmoths, atrazine-resistant common lamb's quarter, Mefenoxam-resistant *Phytophthora*, and ALS (acetolaclate synthase)-resistant ragweed. Resistance develops from overuse of the same pesticide or from overuse of a class of pesticides with a common mode of action, such as organophosphates or ALS herbicides. With overuse, only those pests resistant to the pesticide survive and reproduce, leading to a serious control problem. Therefore, it is important to use pesticides only when necessary and rotate pesticides and mode of action as much as possible.

CHAPTER 1

Review Questions

Chapter 1: Integrated Pest Management

Write the answers to the following questions and then check your answers with those in the back of the manual.

1. Define integrated pest management.

2. List three control strategies and give an example of each.

3. Define economic threshold.

4. A high-value crop will usually have a high economic threshold.

   A. True

   B. False

5. Field scouting is important because it helps determine pest:

   A. Presence.

   B. Location.

   C. Life stage.

   D. All of the above.

6. When scouting a field, you should sample only from:

   A. Border rows.

   B. One small area of the field.

   C. Randomly picked locations throughout the field.

   D. The edge of the field.

7. List three ways that cultural controls work.

8. Which of the following is an example of a biological control?

   A. Parasitoid

   B. Cover crop

   C. Pesticide

   D. Tillage

9. Host plant resistance is a form of:

   A. Biological control.

   B. Chemical control.

   C. Cultural control.

10. When plant species eliminate other plants by releasing toxic chemicals, it is called:

    A. Phytotoxicity.

    B. Allelopathy.

    C. Sanitation.

    D. Carryover.

11. After the growing season, destroying or removing crop residue can help reduce potential insect and disease problems the following year.

    A. True

    B. False

12. Pesticides are **not** part of an IPM program.

    A. True

    B. False

13. Herbicides that are applied and mixed into the soil before crop planting are called ______________ herbicides.

    A. Preemergence

    B. Postemergence

    C. Preplant incorporated

    D. Seed treatment

14-18. Match the following scenarios with the type of pesticide application you would perform to combat the problem.

A. Preventive

B. Curative

14. ___ Very weedy cornfield; the corn is knee-high.

15. ___ A neighboring field is infected with a disease and you don't want it in your field.

16. ___ The MSU Crop Advisory Team alerts you to potential pest outbreaks in your area.

17. ___ You apply a fungicide to get rid of a disease.

18. ___ When scouting a potato field, you find that the potato leafhopper population is above the economic threshold.

19. How are tolerance and pesticide residues related?

20-23. Match the following with their definitions.

A. Predators

B. Biological control

C. Pathogens

D. Parasitoids

20. ___ Typically a fly or tiny wasp that develops inside another insect.

21. ___ Generalist (organisms that eat almost anything).

22. ___ Using living organisms to control a pest.

23. ___ Viruses or bacteria.

24-27. Match the following words with their definitions.

A. Pesticide resistance

B. Reentry interval

C. Preharvest interval

D. Phytotoxicity

24. ___ Reduces unnecessary exposure of workers to pesticides.

25. ___ Damage to a crop caused by pesticide application.

26. ___ Avoids harvesting pesticide-contaminated crops.

27. ___ Can result from the continued use of the same pesticide.