

# CHAPTER 1

# INTEGRATED PEST MANAGEMENT

## LEARNING OBJECTIVES

After completely studying this chapter, you should:

- Know the goal of integrated pest management (IPM) programs.
- Be familiar with IPM components and how they are used.
- Understand the concept and use of threshold levels.
- Be able to define and describe management methods, including cultural, biological, mating disruption and chemical methods.
- Understand the importance of preharvest interval, residues, reentry interval, phytotoxicity and pesticide resistance.

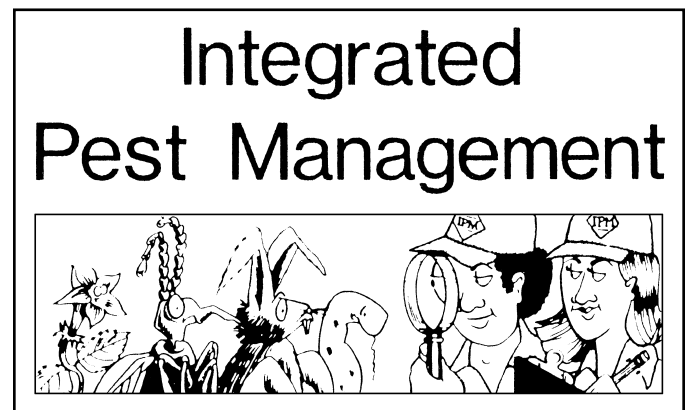
Fruit crops are vulnerable to attack by pests. Pest damage can range from leaf damage that has no effect on the value of the fruit to severe damage that kills plants, significantly reduces crop yield or reduces the crop's market value. Pests may also cause contamination of fruit at harvest, reducing its marketability. Fruit pests include insects and mites, pathogens, nematodes, weeds and vertebrates.

Effective pest management 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)

Integrated pest management (IPM) is an ecological approach to pest management. In general, pest elimination is not a goal of IPM. Rather, IPM seeks to use all appropriate tools and tactics to keep pest populations below economically damaging levels while avoiding adverse effects to humans, wildlife and the environment. Based on information gathered about the pest problem and the crop, management decisions are made using a combination of control measures that best suit the problem.

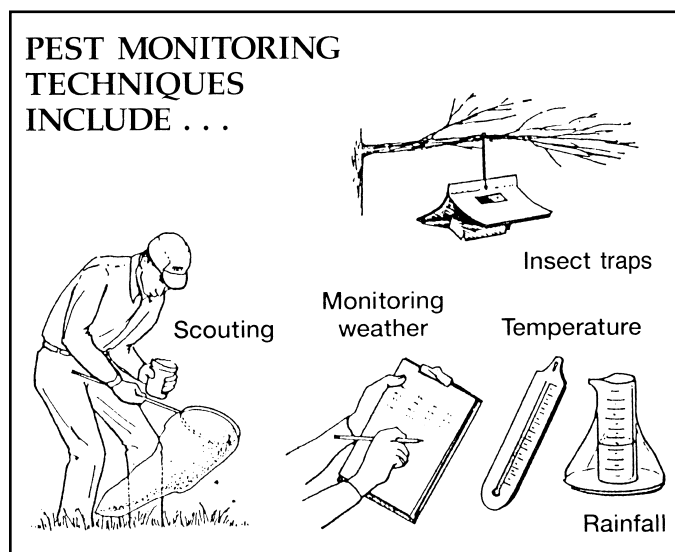


The components of IPM are:

- Monitoring (scouting).
- Forecasting.
- Thresholds.
- Choosing management methods.
- Evaluation.

## MONITORING (SCOUTING)

Monitoring or scouting is the fundamental component of any IPM program. By providing the grower with timely information on pest and natural enemy populations, monitoring helps the grower determine if control methods are necessary and provides information on the effectiveness of control methods already used. Regular scouting of orchards and 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 size of the pest population and whether it is increasing or decreasing, and the crop condition. A scouting program should include accurately written records of field or orchard locations, field conditions, previous pest infestations and control measures. With this information, you can determine what control measures are appropriate.



Correct identification and location of each pest in a crop are essential for precise and effective pest management decisions. The life cycle and capabilities of the pest help determine what monitoring and control choices to make. Many resources are available through Michigan State University Extension (MSUE) and Michigan State University (MSU) to assist growers in correctly identifying pests and natural enemies.

It is impossible and unrealistic to check every part of every plant or tree, so effective scouting is based on gathering information from a representative sample. Information gathered from the sample is used to make assumptions about the entire field or orchard. Correct sampling methods vary by pest and crop but usually require gathering information from several locations throughout the orchard or field and the tree or plant. Insect pests can be monitored in several ways. The most common methods used for monitoring fruit pests are described below.

1. **Visual counts:** This involves 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., num-

ber of insects per leaf). Insect crop damage is often expressed as percentage of the plant damaged (e.g., percent leaf defoliation).

2. **Leaf brushing:** This method facilitates counting small pests and is most commonly used for mites and pear psylla. Leaves are inserted into a special machine that brushes the mites or psylla onto a glass plate with a grid, making counting easier.

3. **Beating tray:** This method involves jarring the insects from the plant by tapping limbs or shoots with a stiff rubber hose and collecting the insects on a cloth-covered tray placed beneath the plant. Insects such as pear psylla, plant bugs, large caterpillars, and predators of pear psylla and aphids can be collected and counted using this method.

4. **Pheromone traps:** Pheromones are chemical signals used by insects to communicate with others in the same species. The pheromones used in monitoring traps are usually synthetic versions of chemicals produced by females to attract males for mating. These chemicals are very specific, so the captures usually consist of males from one species of insect. Pheromone traps are available for detecting most of the major moth pests in fruit crops in Michigan. These traps can be used to:

- Assess the time of emergence.
- Determine the level of pest activity in a crop.
- Determine the optimum time to apply a control measure.

In some situations, cumulative male catch in traps can also be used to determine the need to control a pest.

5. **Other traps:** Light traps, sticky traps and bait traps all have uses in a monitoring program. Sticky spheres baited with an attractant (usually a mixture of protein hydrolysate and ammonium acetate) are used to monitor fruit flies, including the cherry fruit fly, apple maggot and blueberry maggot.

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.

## THRESHOLDS

An **economic injury level** is defined as the pest density at which the cost of the damage is equal to the cost of control. Economic injury levels are a function of crop value and cost of control. In general, a high-value crop will have a lower economic injury level — less pest damage will be accepted and control measures must be implemented sooner. If the control measures are expensive or the value of the crop is low, the economic injury level is usually high. High control costs means it takes more crop loss to justify the control action.

An **action threshold** is the point at which control measures are required to prevent the pest populations from increasing to the economic injury level. When the pest population reaches the threshold, action is taken to reduce the population. The action threshold is lower than the economic injury level to allow time for the control to work. For insects, an action threshold is typically expressed as the number of insects per plant or per leaf or the amount of crop damage. This threshold can vary, depending on the populations of the pest's natural enemies. If there is a high population of natural enemies, higher populations of the pest can usually be tolerated.

## FORECASTING

Weather data and other information help predict when specific pests will most likely occur. Models have been developed for several important pests of fruit crops. The rate of spread and growth of many diseases is largely determined by temperature and the amount of moisture and precipitation present at vulnerable times for the crop. The adapted Mills Table that is commonly used in Michigan for predicting apple scab infection is based on air temperature and duration of wetting periods.

### Growing Degree-day Models

Degree-day models, combined with monitoring, can enable the grower to determine the most effective time for treatment applications. Because insects are cold-blooded, the growth of adults, larvae and eggs is driven by the temperature of their surroundings. The dormant overwintering stages require a certain amount of heat before they reach the stage for emergence. During this development, there is a lower limit below which no growth happens, and as the temperature increases above that, the insects grow faster and faster, up to a maximum limit. Based on the understanding of how temperature affects insect growth, growing degree-day models predict when insect pests will emerge and become active. Weather varies from season to season, so applying treatments based on the stage of the pest is much more effective than using calendar dates. These models predict the appearance of insects, egg-laying activity and other important events based on the amount of heat accumulated in the vineyard, bog or orchard.

One degree day is accumulated when the average temperature for a day is 1 degree over the lower limit for development. *Growing degree-days (GDD)* are the total number of degrees for insect growth that are accumulated during one day. At the end of every day, these numbers are added to the previous daily total to create a cumulative number of GDD. The start point for accumulating degree-days is decided one of two ways — either GDD are counted from a set date, such as January 1, or they are counted from a specific biological event, called a **biofix**. This is often the first sustained capture of an adult in a pheromone or other trap. Using a biofix is usually more accurate. It also means that GDD have to be counted for a shorter period. For many of the apple and cherry pest insects, the number of GDD from first sustained moth catch to egg hatch is well known.

The MSU agricultural meteorology program has weather stations placed around the state and provides running totals of GDD at both the 42°C and 50°C thresholds on the Internet at <<http://www.agweather.geo.msu.edu/agwx/current>>. Temperature is site-specific, however, so there is no substitute for temperature measurements taken in your crop. Temperature conditions can vary greatly even within one farm, depending on the direction of the ground's slope and the presence of cold-air traps. It is not unusual for some insects to appear a week apart in different fields on the same farm. Monitoring traps should, therefore, be placed in different parts of the farm so that different timings can be followed. The easiest way to obtain a rough calculation of degree days for a specific day is to add the daily high and low temperatures (using a min-max thermometer) and divide by two. Then subtract the lower limit for growth of the target insect. By making this calculation each day, you will become more accurate in your pest management, and that should lead to better control through more accurate timing of applications.

## MANAGEMENT STRATEGIES

### CULTURAL PRACTICES

Cultural management manipulates the environment to make it more favorable for the plant and less favorable for the pest. Like all other control strategies, cultural control requires an understanding of the pest and the crop. Cultural control measures are usually applied at the most vulnerable stage of the pest's life cycle and are generally preventive rather than curative actions.

#### Cultural control methods work in three ways:

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

#### Examples of cultural control in fruit:

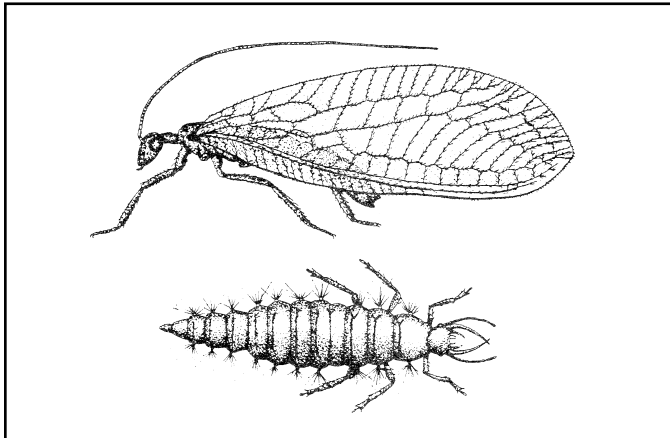
- Orient the planting to provide maximum drainage and air circulation.
- Plant insect- and disease-resistant or -tolerant varieties or rootstocks. This can be one of the simplest ways of reducing expensive treatments and negative environmental impacts.
- Remove overwintering sites — such as cull piles, mummies, suckers and damaged trees — and alternate hosts to minimize damage by insects and diseases.
- Prune to eliminate optimum sites for pests and enhance penetration of sprays.
- Manage irrigation schedules to avoid long periods of high relative humidity, which encourage some diseases to develop.
- Manage fertilizer to limit the excessive plant growth preferred by plant-sucking insects.

- Maintain a ground cover that provides habitat for beneficial insects.
- Use physical barriers to separate the pest and the host. Examples include putting netting over blueberry plantings to protect fruit from birds and covering the soil with black plastic to control weeds.
- Maintain strong, healthy plants that are well equipped to outcompete weeds, fight disease and withstand insect damage.

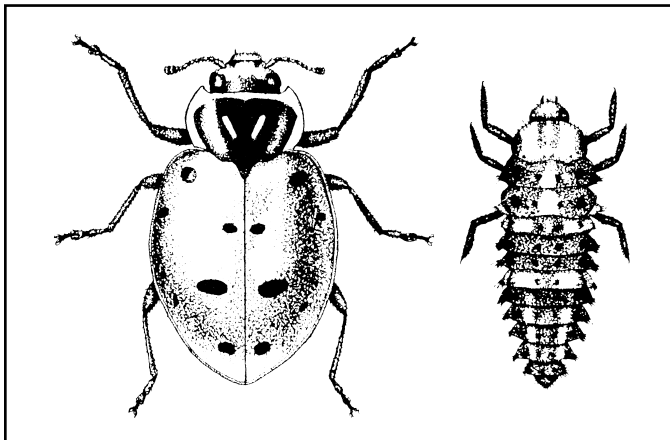
## BIOLOGICAL CONTROL

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.

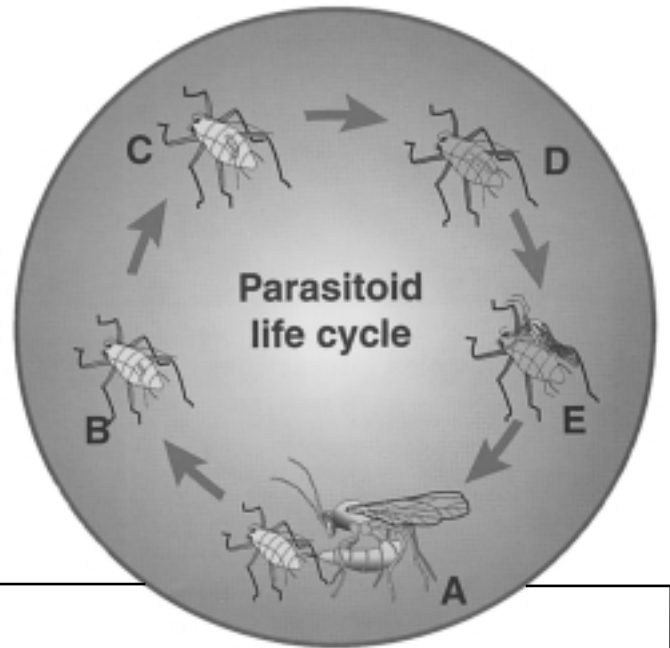
- **Predators** — other organisms that eat the pest. Predators are usually not specific and will eat a variety of pests.
- **Parasitoids** — organisms that must live in or on another organism to complete their life cycle. A parasitoid is usually an insect that develops and feeds inside another insect. An adult parasitoid lays an egg in or on a host insect. When the parasitoid egg hatches, the parasitoid larva feeds on the host



Green lacewing adult and insect-eating larva.



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



- 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.

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.

- **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 (epizootics), 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.

## MATING DISRUPTION

Mating disruption is becoming a valuable management tool for some fruit insect pests. Female insects secrete chemicals called sex pheromones to attract males of the same species for mating. Mating disruption usually involves flooding a planting or orchard with large amounts of an insect's sex pheromone to prevent potential mates from locating one another and mating. Mating disruption products are considered to be essentially non-toxic and environmentally benign.

Currently the most common products involve dispensers placed within the tree canopy or field, but new methods of dispensing pheromone, including sprayable pheromones, are being developed. Mating disruption does not kill the targeted insect but reduces the popula-

**Examples of insect biological control agents (natural enemies).**

Natural enemy	Pests controlled
<b>PREDATORS</b>	
lady beetles green lacewings syrphid flies minute pirate bug predatory mites	aphids, other small soft-bodied insects aphids, mites, mealybugs, pear psylla aphids, scale insects, thrips mites, aphids, thrips spider mites, rust mites
<b>PARASITOIDS</b>	
tachinid flies ichneumonid wasps braconid wasps <i>Trichogramma</i> wasps	caterpillars, beetle larvae and stink bugs larvae and pupae of many insects caterpillars, aphids eggs of many insects, including codling moth
<b>PATHOGENS</b>	
<i>Bacillus thuringiensis</i> (bacterium) codling moth granulosis virus <i>Agrobacterium radiobacter</i> strain K84 (bacterium)	caterpillars, some beetle larvae, mosquito and blackfly larvae codling moth larvae crown gall

tion levels of the pest by preventing mating and reproduction. Treating fruit crop environments with disruption products can help reduce broad-spectrum insecticide inputs, providing an opportunity for natural enemies of pests to establish and survive in fruit plantings.

**CHEMICAL CONTROL**

Chemical control reduces a pest population through the application of pesticides. In an IPM program, pesticides are used only if pest pressure, monitoring, economic thresholds or disease forecasts indicate a need. When used properly, pesticides provide effective and reliable control of many pest species. Pesticides can be man-made synthetic chemicals, naturally occurring chemicals from plants (e.g., nicotine from tobacco and pyrethrum from chrysanthemum), microorganisms (e.g., *Bacillus thuringiensis*) or minerals (e.g., copper and sulfur).

**Broad-spectrum vs. Selective Insecticides**

Since World War II, broad-spectrum insecticides have formed the foundation of insect management in fruit. Organochlorines, organophosphates, carbamates, and pyrethroids are all groups of broad-spectrum insecticides used in fruit pest management. They have been popular because in general they have been relatively inexpensive and fast-acting, and they provided control of many pests simultaneously. However, there are several disadvantages to these products. The wide use of these products has led to the development of resistance in many key fruit pests. Many broad-spectrum insecticides are toxic to

beneficial insects and mites. This limits buildup of natural enemies and the potential for biological control of pests.

Selective or narrow-spectrum insecticides affect a specific, small group of organisms. They generally provide control of the targeted insect pest while causing minimal disruption of its natural enemies and the environment. Unlike broad-spectrum insecticides, narrow-spectrum insecticides are not contact poisons but must be ingested by the target pest to be effective. They have little or no contact toxicity. Groups of narrow-spectrum insecticides include insect growth regulators (IGRs) (which mimic or inhibit insect hormones), microbials (derived from bacteria or fungi), neonicotinoids (synthetic derivatives of botanical nicotine), insecticidal soaps and horticultural oils. Because of their selective properties, many of these products fit very well with the goal of conserving natural enemies. In an IPM program, these products should be considered when pest management is necessary.

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 at harvest.

**Residues** — the pesticide that remains on the crop after an application. Ideally, a pesticide is present to kill the pest and then breaks down when it is no longer needed. 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 the treated area without personal protective equipment (PPE). The reentry interval prevents unnecessary pesticide exposure. Only workers trained for early entry under the Worker Protection Standards (WPS) and wearing proper personal protection equipment may enter a treated area during the reentry interval. Refer to the Worker Protection Standards for the regulations on informing workers about pesticide applications.

**Phytotoxicity** — when a pesticide damages the crop to which it is applied. Pesticide drift, excessive rates, 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 to avoid this problem.

**Pesticide resistance** — the genetic ability of an organism to tolerate the toxic effects of a pesticide. Examples include carbaryl-resistant leafhoppers, atrazine-resistant common lamb's-quarters, Mefenoxam-resistant *Phytophthora* and ALS (acetolactate synthase)-resistant ragweed. Resistance develops from overuse of either the same pesticide or 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. The result is a serious control problem. Therefore, it is important to use pesticides only when necessary and rotate pesticides and modes of action as much as possible.

## EVALUATION

An important component of an IPM program is to evaluate your management strategies. It is very important to determine how effective your management and control strategies are. This information will determine whether any follow-up treatment is needed and will improve your management strategies for next year. Return to the area after applying a treatment and compare posttreatment pest activity to pretreatment. This is where a pest management logbook and good records become invaluable. Include your observations about where pests first showed up, what kinds of natural enemies you observed, where and when specific treatments were applied, and what the results were. Sound IPM practices pay off both economically and environmentally.

2. Define economic injury level and action threshold.



## 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 and list the components.

3. A high-value crop will usually have a high action threshold.
  - A. True.
  - B. False.
4. Monitoring is important because it helps determine pest:
  - A. Presence.
  - B. Location.
  - C. Life stage.
  - D. All of the above.
5. 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.
6. Define growing degree-day models and explain what they can tell us.
7. List three ways that cultural methods work and give examples of each.
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. Describe how mating disruption works.
11. Pesticides are NEVER part of an IPM program.
  - A. True.
  - B. False.
12. How are tolerance and pesticide residues related?

**13-15. Match the following with their definitions.**

- A. Predator
  - B. Pathogen
  - C. Parasitoid
13. \_\_\_ A disease-causing organism — such as bacteria, viruses and fungi — that infects the pest.
14. \_\_\_ An organism that must live in or on another organism to complete its life cycle.
15. \_\_\_ An organism that attacks, kills and feeds on other pests; usually a generalist.

**16-19. Match the following management methods with their examples.**

- A. Cultural
  - B. Biological
  - C. Mating disruption
  - D. Chemical
16. \_\_\_ Placing large amounts of insect sex pheromone in a field to prevent potential mates from locating one another and mating.
17. \_\_\_ Orienting planting to provide maximum drainage and air circulation.
18. \_\_\_ Using a parasitic wasp to control a pest.
19. \_\_\_ Spraying a herbicide to control weeds.

**20-23. Match the following words with their definitions.**

- A. Pesticide resistance
  - B. Reentry interval
  - C. Preharvest interval
  - D. Phytotoxicity
20. \_\_\_ Reduces unnecessary exposure of workers to pesticides.
21. \_\_\_ Damage to a crop caused by pesticide application.
22. \_\_\_ Avoids harvesting pesticide-contaminated crops.
23. \_\_\_ Can result from the continued use of the same pesticide.