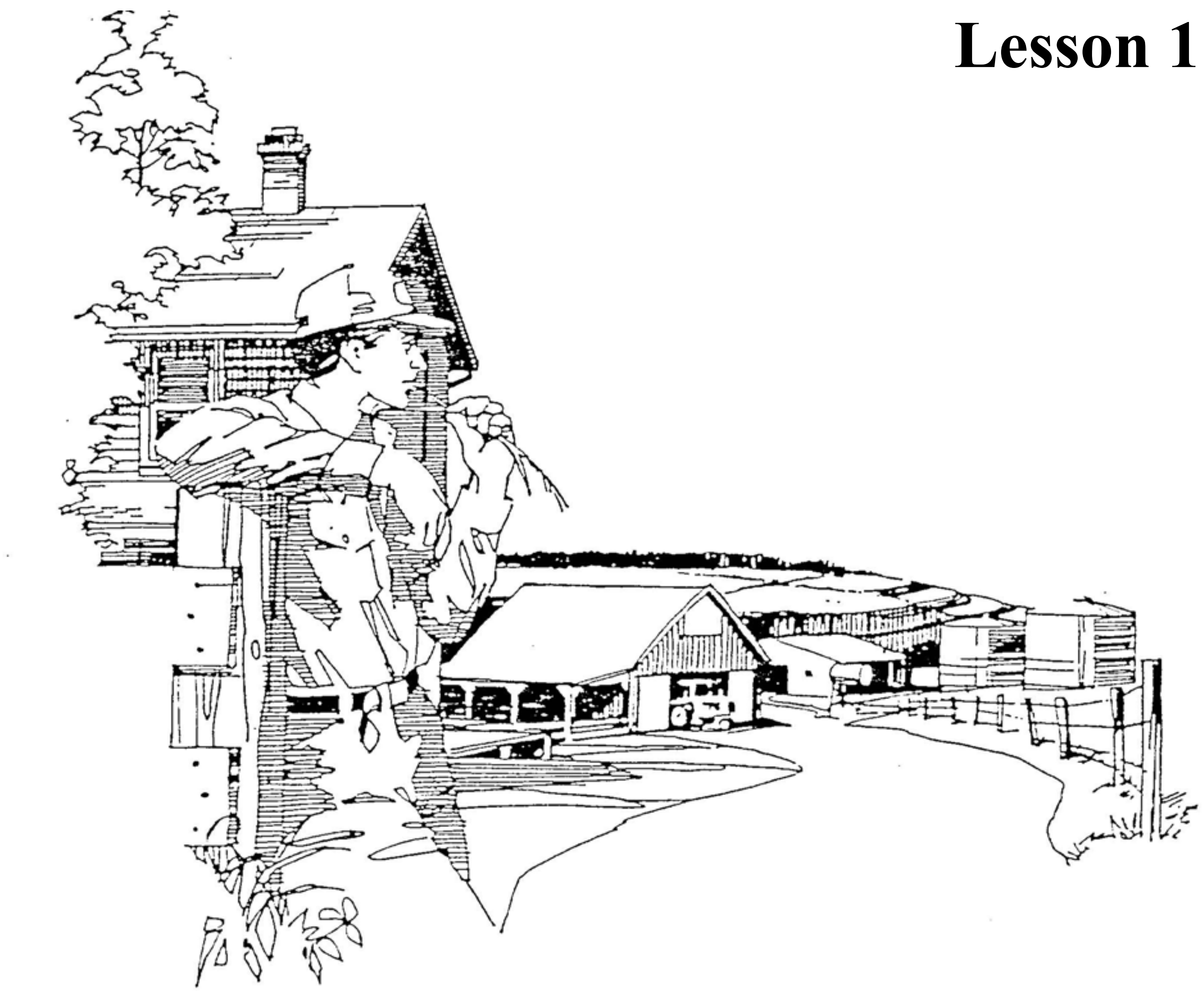
Pesticide Applicator Course for Agricultural Producers

Lesson 10



Pest Management

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Pest Management

What You'll Learn!

The purpose of Lesson 10 is to learn about pests and pest control methods so that you can make pest management decisions using the information on pesticide labels and in your production guide.

Questions in the quizzes and exercises will show the type of information you will need to know for the exam.

By the time you complete this lesson you should be able to:

- **explain what integrated pest management is and the reasons for using it;**
- **describe life cycle stages of insects, diseases and weeds and explain why a knowledge of these stages is important;**
- **describe the five categories of control methods and recognize examples of each;**
- **describe what to consider when making a pest management decision;**
- **define common terms (these are usually shown in bold type);**
- **list steps to take when identifying a pest;**
- **identify the leaf stages of a plant;**
- **explain in general terms how different types of pesticides work;**
- **list factors which affect pesticide application;**
- **use your production guide to find detailed information about pests and their control.**

Some examples are provided to help you understand certain ideas. Those shown in italics are just for help - you will not be examined on them:

Example: ***an example which looks like this is only to help explain an idea. You do not need to memorize it.***

What Is Pest Management?

Controlling pests in the most effective, economical, and safe manner requires much more than a "see and spray" approach. Good pest management includes all these steps:

1. **monitoring for pests and conditions which favor them;**

2. **accurately identifying the pest and knowing something of its habits and life cycle;**

3. **knowing the control methods available;**

4. **making decisions which are most cost-effective and least harmful to people and the environment;**

5. **applying pesticides only as directed for most effective, safe results;**

6. **recording and evaluating results to continually refine the program;**

7. **using integrated pest management to combine the best methods or maximum effect at lowest cost with least hazard, and to avoid development of resistant strains of pests.**

This lesson introduces these ideas and shows how they apply to three major types of pests - insects and mites, diseases, and weeds.

Pest Monitoring

Monitoring is the process of regularly inspecting crops or traps to determine if pests are present in numbers which should be treated, and if they are, at a growth stage most suitable for treatment. Weather conditions favourable to pest development may also be monitored. Methods of monitoring pests can include using traps, counting pests on a number of leaves, or simple observation.

Monitoring allows control action to be taken:

a) **only if and when needed; and**
b) **at a time when it will be most effective.**

It can eliminate or substantially reduce the number of sprays per season.

Example: ***Monitoring with sticky traps is successfully used to detect carrot rust flies. This information can be used to achieve better control with fewer pesticide sprays.***

Example: ***Monitoring with sex pheromone traps in orchards, combined with monitoring air temperatures, predicts when codling moths will require treatment.***

Pest Identification and Biology

Correct identification is the key to good pest management because most treatments will only control certain pests. Accurate identification helps reduce damage to beneficial organisms. A hand lens with at least 10 x magnification may be required.

Sometimes it is easier to identify the damage caused by the pest than to locate the pest itself. This is true not only of microscopic disease organisms but of pests which remain out of sight.

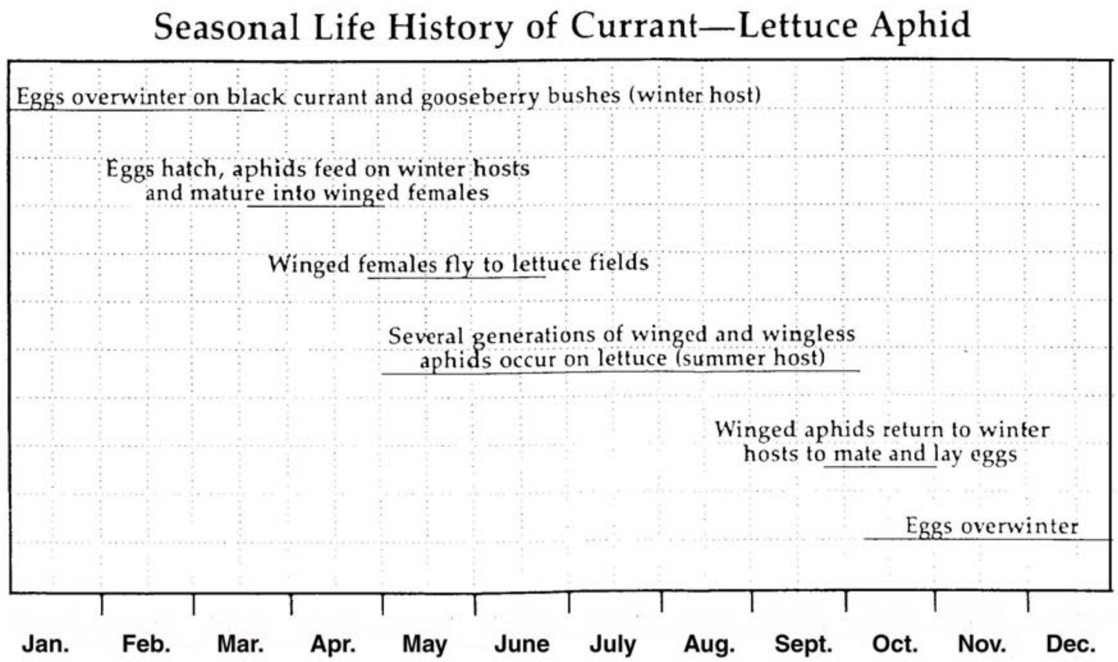
Example: ***cutworm damage to cabbage seedlings is easily identified, but the pest can only be found by digging in the surrounding soil.***

Vectors are organisms which may not be pests themselves but need to be controlled because they are carriers of disease.

Example: ***leafhoppers spread the aster yellows virus in carrots.***

Knowledge of the pest's life cycle, behavior, and natural enemies may be necessary to make effective management decisions. Finding out how often a pest reproduces helps determine how often it must be treated. Identifying the stages of a pest not only helps identification but also ensures that controls are applied at the most effective stage.

Examples: ***annual (a plant which lives for only one year) weeds are easier to control in the seedling stage than at later stages; most perennials (a plant which lives for 2 years or longer) may also be controlled in the bud to early flowering stage; many insects are best controlled when they are immature.***



Knowing the seasonal life history of a pest helps anticipate problems and identify ways to disrupt the cycle. Some pests overwinter on other crops or on weeds.

Methods of Pest Control

There are usually many ways to control pests. Most are simply good farming practices which encourage crop growth yet discourage pest infestations. They try to prevent a pest getting a start or reaching levels where damage is so severe that costly treatments are needed. An effective control program uses a combination of pest management methods.

Pest management methods can be divided into five categories: sanitary, cultural, mechanical, biological, and chemical.

Sanitary

Sanitary control is not giving pests a place to breed or a way to spread. This includes such steps as:

- **destroying plant trash which can harbor pests;**
- **controlling vectors which can carry disease (e.g., some insects);**
- **controlling weeds in ditches, along roads, fencelines, etc.;**
- **sterilizing soil and equipment in greenhouses.**

Cultural

Cultural control is growing crops in a way which discourages the pest from becoming established. This includes such actions as:

- **choosing crop strains with natural resistance to the pest;**
- **rotating crops to break the life cycle of the pest;**
- **following good growing practices (proper fertilizers, irrigation, etc.) that strengthen crops, make them more resistant to damage by insects and diseases, and allow them to compete more successfully with weeds.**

Mechanical

Mechanical (or physical) control means using mechanisms to keep out, kill, disrupt, or capture pests. This includes such methods as:

- **tillage and mowing of weeds;**
- **screens on greenhouse openings;**
- **fences, nets, noisemakers, or traps.**

Biological

Biological control is the use of pest predators, parasites, diseases, and lures to help keep pests at manageable levels. This includes the use of such beneficial organisms as:

- **the syrphid fly, which eats aphids in fields and on vegetables;**
- **grazing animals, which eat weeds;**
- **decoy sterile insects, which lure breeding insects away from fertile mates so that fertile egg production is reduced.**

Example: ***predatory mites control two-spotted mites and western flower thrips on greenhouse cucumbers; the small parasitic wasp Encarsia formosa is used in greenhouses to control whiteflies.***

These natural enemies of pests are called beneficial organisms because they benefit the grower - they are a grower's natural allies. Pollinating insects such as bees are also beneficial organisms. Control methods should be selected which will not destroy them and will not totally eradicate the pest they prey on.

Example: ***conserving a moderate number of apple rust mites is important. They are a valuable alternate food source for predator mites early in the season before European red mites appear.***

Chemical

Chemical control is the use of pesticides such as insecticides, miticides, fungicides, herbicides, and rodenticides.

Although pesticides are very effective, they should be used only when absolutely necessary in order to minimize:

- **risk to the applicator and fieldworkers;**
- **development of pest resistance to pesticides (a resistant pest is one which has developed a natural immunity to a pesticide);**
- **damage to beneficial organisms;**
- **pesticide residue on food crops;**
- **risk to the environment (for example, reducing pesticide exposure of birds and other wildlife, preventing pesticide runoff into streams and lakes, and preventing contamination of groundwater).**

Some contact pesticides have a residual effect. This means they can be effective for some time after they are applied. The length of the residual effect depends on a number of things including soil type, climate, moisture, etc.

Some pesticides are selective (specific); that is, they affect only certain pests and not others. Others are non-selective (non-specific) they will kill many living things.

Example: ***there are selective miticides which reduce pest mites but do not eliminate beneficial predator mites. And there are selective herbicides which may be used in crops which will reduce weed competition without harming the crop.***

Pest Resistance

Heavy reliance on chemical controls in recent years has led to the development of pests which are resistant to pesticides.

> **"Populations of several insect pests now have such a high proportion of individuals resistant to all known insecticides that substitute materials are no longer available and insecticides are not recommended as control measures. Chemical control in these instances is no longer the method of choice. We are literally exhausting our arsenal of chemical tools."**

George Ware, University of Arizona, The Pesticide Book, 1978

A rancher can breed better cattle by selecting those with desirable traits to become parents. In the same way a grower could also unknowingly select resistant pests in his or her fields.

How does this happen? Pests can produce thousands of offspring so the chance of variation of certain characteristics occurring is high. Offspring born with characteristics that make them more resistant to a pesticide may survive. They soon multiply and pass on their resistance to thousands of offspring. Each successive treatment of the same or similar pesticide repeats the process, actually selecting and breeding a strain of resistant pests. Eventually that chemical and others similar to it become less and less effective.

Reliance on pesticides only, especially on those from one chemical group, helps to create resistant varieties of pests. Development of pest resistance can be slowed by:

- **using a variety of control methods, particularly non-chemical ones;**
- **only using pesticides when needed;**
- **alternating pesticides from different chemical groups.**

Making Pest Management Decisions

Once a pest has been identified and possible control methods have been determined, ask yourself:

1. **What loss will the pest cause if not controlled?**

2. **How much will each control method cost and how effective will they be?**

3. **What are the risks to the applicator and environment of each control method?**

4. **Is it possible to combine control methods for more economical and effective results?**

With rare exceptions, it is not necessary to eliminate all pests. The goal in most pest management programs is to control pest levels in the most economic and safe manner possible.

Keeping Records to Evaluate and Refine Your Program

The best decisions are based on information which is specific to your land, your crops, your pests, your weather, and your farming methods.

Use written records to note for future use such details as:

- **which pests you've experienced, where, what levels, and when;**
- **controls you've tried, when, what conditions, and costs (make special note of residual pesticides);**
- **the crops planted - varieties, rotations;**
- **cultural practices - when planted, harvested, fertilized, etc.;**
- **the results you noticed.**

Having this information will later help you evaluate what worked and what didn't, and enable you to plan better prevention and treatment for the future.

Integrated Pest Management (IPM)

Integrated pest management or IPM is an approach to pest control which integrates the preceding management practices and control methods into one pest management program. IPM principles include:

1. **Prevent - use sanitary control, resistant crops, rotation, and other methods which will keep pests from becoming a problem.**

2. **Understand - learn a pest's life cycle and habits to make strategic decisions about when, how, and where to control it.**

3. **Monitor - watch pest levels and weather conditions to anticipate when controls are actually needed and will be most effective.**

4. **Tolerate - controlling pests does not always mean killing every one. Usually there is a tolerable level which will not cause economic damage (and may even be needed to maintain a natural balance of beneficial predators).**

5. **Evaluate - compare the cost (and risk) of controls to the cost of tolerating some crop damage. Act only when it is clear that the benefits are economically and environmentally justifiable. Record actions and results.**

6. **Combine - use a wide range of compatible cultural, biological, and chemical methods.**

The goal of IPM is effective, economical, and environmentally safe long-term pest control. Pesticides should be used only when essential.
Some of the immediate benefits of IPM include:

- **enjoying more cost-effective pest control;**
- **slowing the development of pest resistance;**
- **reducing dependence on one type of control.**

IPM also addresses consumer and governmental concern about the careful use of pesticides. Legislation and consumer fears are already limiting pesticide use and this trend may accelerate unless the public believes that pesticides are being used in a responsible manner.

In summary: IPM brings together monitoring, a knowledge of pest biology, and the use of all available control methods in order to create a program which is as cost effective and environmentally safe as possible.

What Happens Next?

This section has been a general introduction to pest management. You'll review what you've learned in the following quiz. The remainder of this lesson illustrates these ideas in further detail as they apply to insects, diseases, and weeds. After checking your quiz answers, move on to Exercise 10.1.

Quiz 10.1 - General

Complete the following questions.

1. **What is "monitoring" and why is it done?**

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2. **Why should you be able to accurately identify a pest? Give two reasons.**

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3. **Why is it important to be able to identify the stages of a pest?**

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4. **List the five categories of pest control methods used in this lesson and very briefly define each one:**

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5. What is a "beneficial organism"?

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6. List three reasons why pesticides should be used only when necessary.

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7. What does it mean when a pesticide has a "residual effect"?

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8. What is the difference between a "selective" pesticide and a "non-selective" one?

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9. List three ways to help prevent the development of pest resistance.

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10. What are two reasons for keeping records of pests, controls used, etc.?

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11. What is the main idea of integrated pest management?

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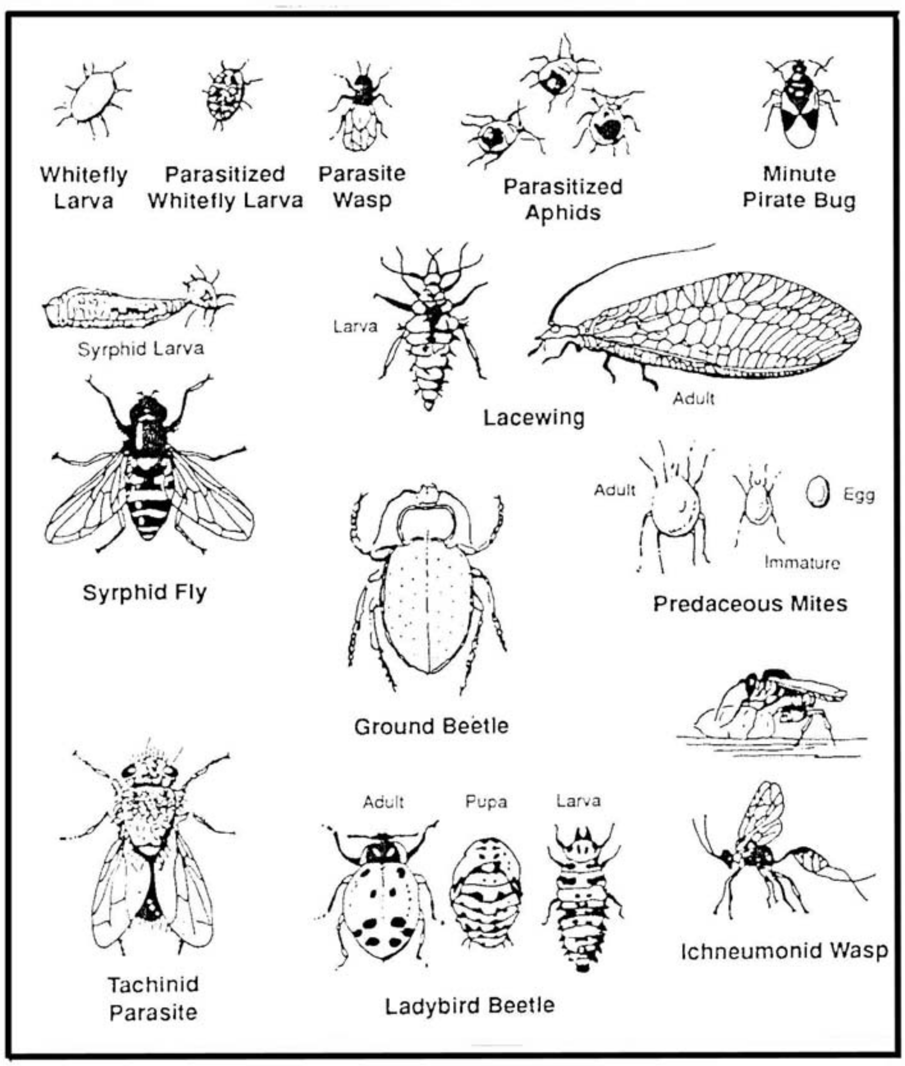
Compare your answers with those in the Quiz Answer Key at the back of this lesson before continuing. Review and retry any sections that you found difficult.

Insects, Mites, and Their Control

There are over 54,000 species of insects and their relatives (mites, spiders, and ticks) in Canada. Most insects are beneficial. Bees and some other insects pollinate crops. Insects such as ladybird beetles, lacewings, and ground beetles eat pest insects, and predatory mites control pest mites.

The following diagram shows some predators, parasites, and examples of parasitized pests.



Life Cycle of Insects and Mites

Knowing the life cycle of pests will help you choose the best method and time for control. Insects and mites change as they grow, going through three or four different stages.

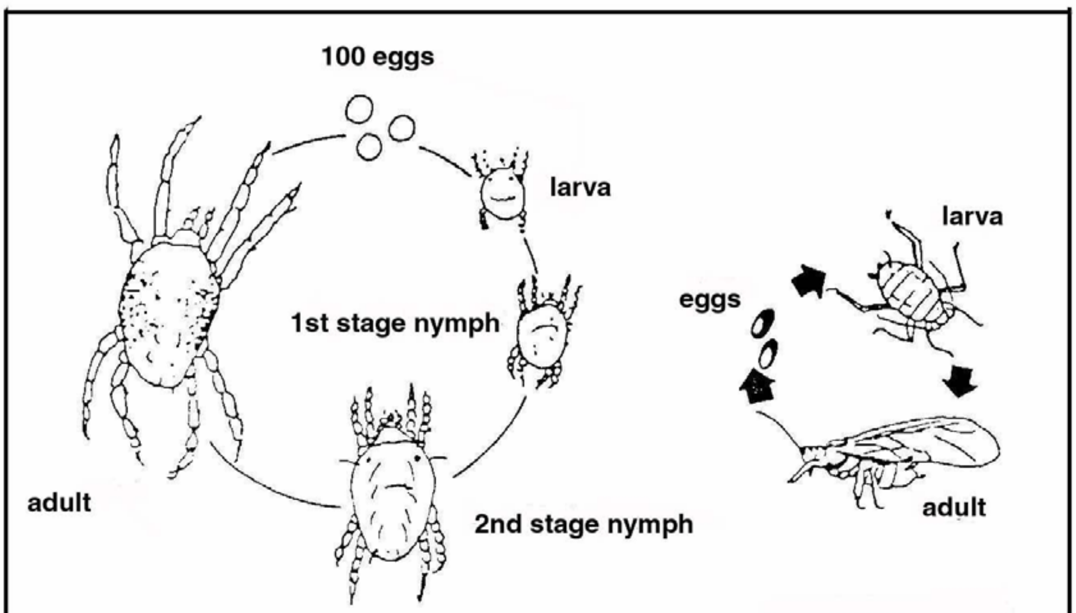
All insects begin as eggs and go through one or more stages before becoming adults. The three most common sequences are:

1. **Egg to young to adult - a young insect looks much like the adult but is less developed.**

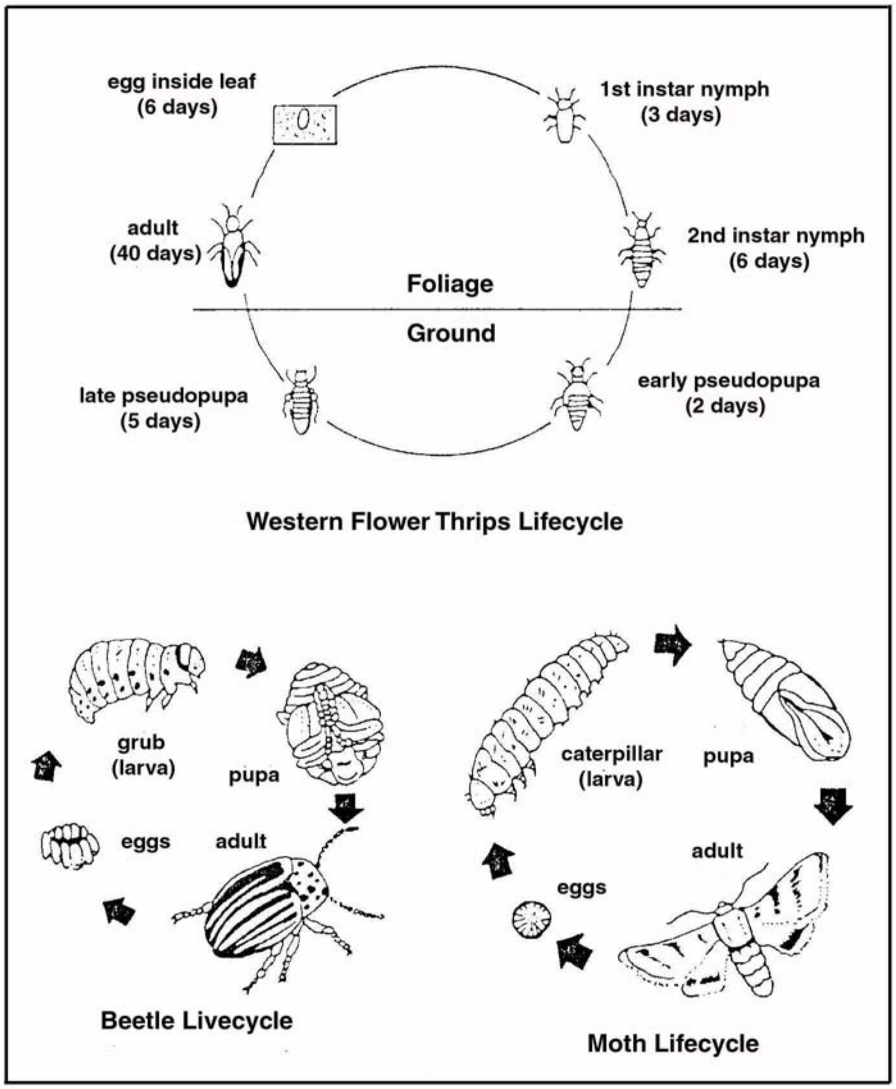
2. **Egg to nymph to adult - a nymph is somewhat different from the adult (for example, it may have no wings or more legs).**

3. **Egg to larva to pupa to adult - the larva is the young, wingless feeding stage (such as caterpillars, loopers, grubs, maggots); the pupa is a resting stage during which complete metamorphosis (change of shape) occurs.**

Mites generally go through four stages: egg to larva to nymph to adult.



Spider mite Lifecycle



The best insect control is usually done during the early stages - immature, nymph, or larva. Eggs and pupae are not affected by most insecticides. Adults are often more resistant to pesticides and may lay eggs before being controlled. Check for pests regularly so you can control them during their most vulnerable stage.

Example: ***the cabbage root maggot is best treated just after hatching. The date when eggs will hatch can be forecast based on monitored temperatures and checking plants for the presence of eggs.***

Knowing how many generations of a pest will occur in one growing season indicates how often a control needs to be applied - once or several times.

Insect and Mite Resistance

Heavy reliance on chemical control methods alone has led to the evolution of insects and mites which are resistant to insecticides.

A pest resistant to one pesticide is often resistant to others in the same chemical group (e.g., all organophosphates) and even to others which work in a similar way.

Example: ***some insect cross-resistance has been noticed between carbamates and organophosphates which both affect the insect's nervous system.***

If an insecticide is not working, or if you need to use it more often, your pests may have become resistant to it.

You can slow the development of resistance by:

- **using non-chemical control methods;**
- **using pesticides only when needed;**
- **alternating pesticides from different groups (for example, a carbamate, then an organochlorine).**

Insect and Mite Management Methods

Insects and mites can be managed by the five categories of control methods mentioned earlier. A combination of methods using IPM principles is desirable. Below are some examples of how these methods are applied to insects and mites.

1. Sanitary control methods can include:

- **destroying or burying debris where insects may live (these are a common source of reinfestation);**
- **controlling nearby weeds which may serve as a source of alternate food;**
- **steam-sterilizing greenhouse and seedbed soil;**
- **cleaning and disinfecting greenhouse containers and tools;**
- **washing soil off machines being moved between farms.**

2. Cultural control can include:

- **rotating crops to break the life cycles of the insects (alternating crops which are not susceptible to the same pests prevents pest buildup);**

- **adjusting planting and harvesting times in relation to the insect's life cycle when possible.**

Examples: ***delaying planting of rutabaga fields until after the first generation of cabbage root maggot has occurred; delaying the harvest of potatoes until several days after the tops have died to reduce blight in storage.***

3. Mechanical control may include:

- **placing screens on greenhouse vents and sealing cracks;**
- **using yellow sticky traps to control low greenhouse populations of whiteflies or thrips and to monitor levels;**

- **using vacuums to remove insects from plants (vacuums range in size from hand-held units to field machines);**
- **disrupting the insect's environment.**

Examples: ***mowing the tops of mature carrots can reduce rust fly numbers;.***

4. Biological control - beneficial organisms are increasingly used to keep certain insects and mites at manageable levels. Most often this involves protecting naturally-occurring ones, but some beneficial organisms can also be purchased from commercial suppliers. Examples of biological control include:

- **a small parasitic wasp, *Encarsia formosa*, used in greenhouses to control whiteflies;**
- **predatory mites can control pest mites on apples and strawberries;**
- **larvae of ladybird beetles, lacewings, and hover flies eat aphids;**
- **bacteria (microbial insecticides) are sprayed to control certain insects. An example is *Bacillus thuringiensis* or B.t. (Dipel).**

5. Chemical control includes a wide range of insecticides, many of them specific to particular insects.

Types of Insecticides

Insecticides are often described according to how they work:

1. Contact insecticides are poisons which must come in contact with the pest. They can be sprayed on the pest, on plants it eats, or on surfaces it touches. Some contact insecticides have a residual effect and can kill insects for some time after they are applied.

2. Systemic insecticides enter plants or animals and flow in the sap or blood to protect them. Insects or mites which suck the sap or blood are killed by the insecticide in it.

Example: ***systemics control sap-sucking insects such as aphids and leaf miners on plants as well as lice and warble grubs in cattle.***

Some insecticides are both contact and systemic.

Example: ***dimethoate (Cygon or Lagon) is both a contact and systemic insecticide for use on plants.***

3. Suffocating insecticides (usually oils) clog the breathing system of insects and may affect eggs.

4. **Fumigants are insecticides in gaseous or vapor form. They are used to kill pests in enclosed spaces or in soil.**

5. **Growth regulators act like the insect's own growth hormones. They affect the normal development of the insect and it dies before it becomes an adult or before it can reproduce.**

6. **Microbial insecticides contain tiny organisms that will kill the insect when they are eaten. They are sprayed on plants. An example is *Bacillus thuringiensis* or B.t. (Dipel). They are only poisonous to certain insects and do not harm beneficial insects.**

Protecting Beneficial Mites

A few pesticides are both insecticides and miticides (such as malathion) and will kill beneficial predator mites. Protect beneficial mites by checking the mite toxicity of potential insecticides. Some miticides are selective, reducing pest mites but not eliminating predator mites. Do not spray for pest mites if there are enough beneficial mites to control them. To identify and help determine mite populations contact an agricultural representative or crop specialist.

Quiz 10.2 - Insects and Mites

1. At which stage is control usually best on insects or mites? (Circle your answer.)

- **a) eggs**
- **b) juvenile (young, nymph, or larva)**
- **c) pupa**
- **d) adult**

2. Give an example of each of the four non-chemical control methods for insects.

a. Sanitary -

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b. Cultural -

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c. Mechanical -

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d. Biological -

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3. What is the difference between contact and systemic insecticides?

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4. List three other types of insecticides and briefly mention how they work.

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Check your answers against the Quiz Answer Key at the back of this lesson, then continue on to the following section.

Diseases and Their Control

What is a disease? Plants are diseased when they develop abnormally. They may exhibit symptoms such as underdeveloped roots, stunted stems, curled leaves, or rotten fruit. These symptoms are the plant's reaction to stressful environmental conditions or to an infecting pest.

Diseases Caused by Environmental Stress

Unfavorable environmental conditions which stress plants and cause abnormal growth include extremes of light, temperature, water, or nutrients.

Examples: ***a shortage of light can cause leaves to turn yellow; spring frosts and unusual cold spells can damage leaves, blossoms, and setting fruits or kill transplants; dry air (low humidity) may increase evaporation from plant leaves and cause wilting; excess water in the soil may cause root hairs to die, reducing water and food uptake; a lack of nutrients can stunt plants; excessive nutrients can cause succulent growth.***

Since the symptoms may be similar to an infection, it is especially important to correctly identify the cause so that treatment is appropriate. This type of disease is not a pest infection so pesticides will not help.

Plants weakened by environmental stress are more likely to be infected by pests. Recognizing and relieving the stress will help prevent infectious disease.

Diseases Caused by Pest Infection

Many plant diseases are caused by pest organisms which get their food from plant tissues. These organisms include fungi, bacteria, and viruses which are frequently too small to see. Identification is generally based on symptoms - you can see the plant's reaction or the structures created by the pest.

Examples of plant's reaction: rot, canker, wilting, stunting

Examples of structures: masses of black powdery spores of smuts; grey fungus body of powdery mildew; mushrooms

Fungi

Fungi are the largest group of organisms that cause plant diseases. Fungi are simple plants which feed on living or decaying organisms. This group includes molds, mushrooms, and rusts.

Most fungi reproduce by tiny spores. When the spores germinate, they usually produce threadlike filaments which can absorb nutrients and give off chemicals that cause disease. The fungi are spread by spores or tiny pieces of the fungus. Movement of infected plants, plant parts, and soil may also spread the fungus.

Some symptoms that may be caused by fungi include cankers, dieback, galls, leaf spots, rots, rusts, and wilts.

Bacteria

Bacteria cause some major plant diseases. Bacteria are one-celled organisms which can only be seen with a microscope. They usually enter a plant through natural openings or wounds. In favorable conditions they reproduce very rapidly using the plant as a source of food. Bacteria are spread from plant to plant by people, equipment, wind, rain, and insects.

Some blights, galls, and rots are caused by bacteria.

<u>Viruses</u>

Viruses cause diseases which often reduce plant vigor and crop yields. They are extremely small organisms which grow inside living cells; they cannot be seen with an ordinary microscope. Viruses are spread by mechanical means (such as during pruning or harvesting) and may also be spread by insects, mites, nematodes, or fungi.

Mosaics, ring spot, and leaf roll are among the diseases caused by viruses.

Disease Characteristics

For successful disease management you must know the cause of the disease and how it develops.

<u>Identifying Diseases</u>

Since disease organisms are microscopically small, identification is difficult. The following steps are useful:

1. **Note patterns of abnormal growth such as parts which are dead, discolored, stunted, or swollen.**

2. **Look for disease structures such as ooze, spore masses, powdery mildew, and mycelia (fungus filaments).**

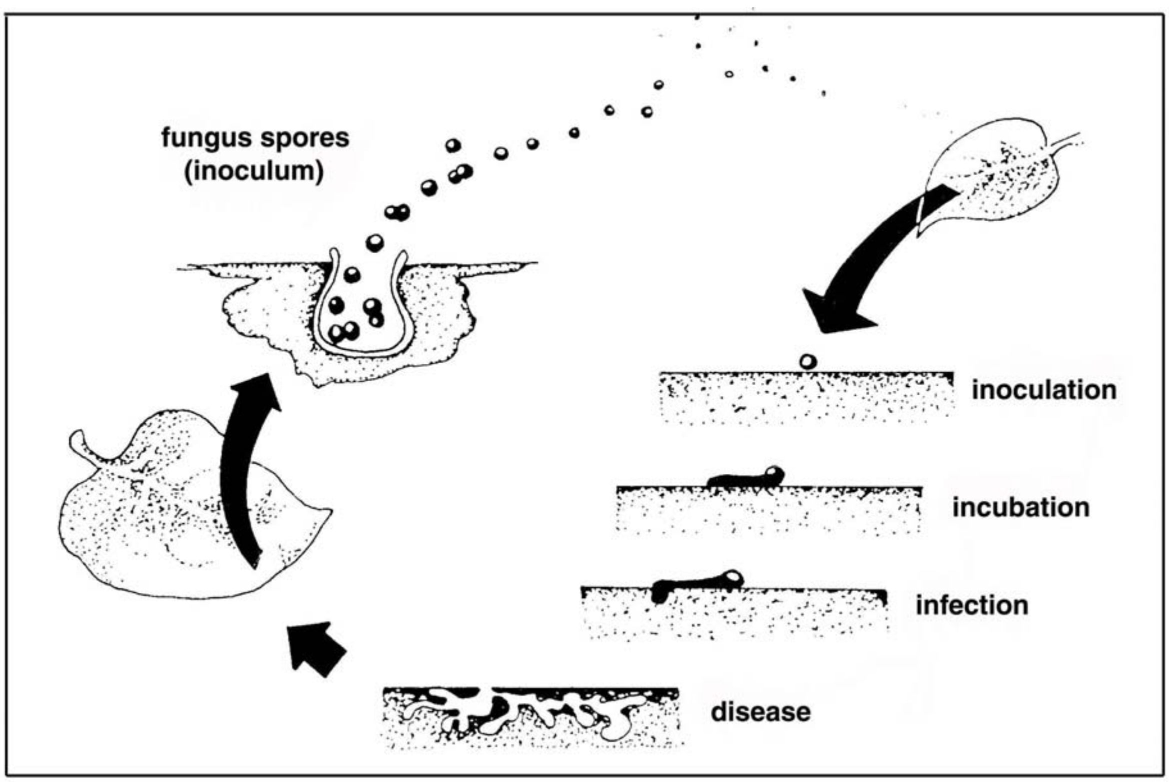
3. **Closely examine the surrounding area. Infectious diseases generally start in one spot and spread slowly and unevenly. If all plants are affected more or less equally, the cause is probably environmental stress - weather, poor cultural practices, or even a toxic chemical.**

4. **Compare symptoms to those of diseases to which that variety is susceptible.**

Information about disease characteristics can be found in production guides and other publications. Assistance is also available from agricultural representatives and crop specialists.

Life Cycle of Disease-Causing Organisms

The life cycles of many disease-causing organisms follow a similar sequence. This order can be shown by using a leaf fungus as an example.



The fungus stays on a diseased leaf over winter. As the weather becomes warmer in spring, the fungus grows and makes spores. As the spores ripen they are released into the air where they are moved by wind or water. Some land on the healthy leaves of a plant. If environmental conditions are poor for spore growth the spores may die, be washed off by rain, or remain dormant. Spores are fairly resistant to pesticides during this stage.

If the environmental conditions are good, the fungus spores will germinate. This is the incubation stage (see diagram) and during this stage the fungus is most vulnerable to pesticides or unfavorable growing conditions.

Infection begins when the fungus is able to enter the plant tissues. When the plant responds to infection by growing abnormally, it is diseased.

Inside the plant the fungus is protected and difficult to control. A systemic fungicide may control the disease if applied before the infection is too severe.

One exception is the powdery mildew fungus which remains on the surface of the plant where it forms special "root cells." Because powdery mildew develops on the outside of the plant, it can be controlled with pesticides after infection has occurred.

Monitoring Weather Conditions

Weather conditions can greatly affect the spread and development of disease organisms. Monitoring weather can help determine if treatment will be needed and, if so, when to apply it.

Approaches to Disease Control

Three things must be present for a disease organism to develop. They are:

1. **a disease-causing organism**
2. **a plant susceptible to the disease**
3. **an environment favorable to the disease organism**

Taking away or changing any one of the above will control the disease.

There are several approaches to disease management. They are:

- **Keep a disease organism out of the area (exclusion).**
- **Use strains of plants not affected by the disease (host resistance).**
- **Get rid of or reduce a disease in the area (eradication or reduction).**
- **Prevent the disease from infecting plants (protection).**

Cultural, biological, physical, and chemical methods of control can be used with all these approaches to disease control.

Infectious Disease Control Methods

Infectious diseases can be controlled by the five methods mentioned earlier - sanitary, cultural, mechanical, biological, and chemical. (However, there is no chemical control for viruses; they must be controlled by host resistance, planting virus-free stock, and preventative sanitation.) Some techniques and examples specific to diseases are:

1. Sanitary control is particularly important against disease and includes:

- **cleaning tools, bins, and machinery;**
- **using certified seed or disease-free plants;**
- **preventing contaminated plants or soil from entering a disease-free area (plant quarantine);**
- **using hot water-treated seeds or bulbs;**
- **sterilizing soil with heat;**
- **keeping fields free of weeds or trash which can harbor disease;**
- **controlling disease-carrying vectors such as insects.**

Example: ***western flower thrips spread the tomato spotted wilt virus (TSWV); controlling the thrips helps prevent virus infection.***

2. Cultural control can include:

- **changing the environment (e.g., pH, drainage, flooding) so the disease organism cannot germinate;**
- **using strains of plants that are not affected by the disease (resistant plants);**

Example: ***disease-resistant alfalfa varieties are used to reduce Verticillium wilt, and disease-resistant rootstocks are planted to prevent Phytophthora crown rot in apple orchards;***

- **rotating crops to deprive the disease of hosts in alternate years; encouraging good plant establishment (a vigorous, unstressed plant is more resistant to disease).**

3. Mechanical control of disease includes:

- **removing and destroying diseased leaves or growth.**

4. Biological control of disease is a relatively new field and includes:

- **treating plants with biological control agents.**

5. Chemical control includes:

- **treating seeds with fungicides;**
- **applying fungicides or bactericides to soil or plants.**

<u>Types of Fungicides</u>

1. Protectant fungicides provide a protective film of fungicide to prevent fungus spores from germinating. Protectants must be used before the fungi reach the infectious stage (see previous diagram of fungus life cycle). After the plant is infected the fungicide normally will not kill the fungi inside the plant, but it can protect the plant from more infection. New plant growth which appears after treatment is not protected.

Protectants can be applied to seeds, foliage, flowers, fruit, or roots. Seed protectants such as captan or thiram are used to prevent seedling blights, root rots, and damping-off. Foliage and blossom protectants such as captan or maneb are used to prevent leaf spot and blossom blight diseases. Fruit protectants such as benomyl, captan, or chlorothalonil are used to prevent fruit blemishes and harvest rots of fruits and vegetables. Most fungicide control programs use protectant fungicides.

2. Eradicant fungicides kill fungus organisms that have started to develop and infect a plant but before they have become well established within it. Eradicant fungicides have limited applications against fungi which have already infected plants. Only a few fungicides are eradicants (for example, dichlone, dodine, and liquid lime sulphur). Some protectants are also eradicants (e.g., benomyl).

3. Systemic fungicides are not common. The few that have been developed are absorbed by plants and move within them. They may act as protectants or eradicants or both. Once inside the plant some systemics move to areas of new plant growth.

<u>Bactericides</u>

Bactericides are chemicals used to prevent bacterial infections. Only one bactericide is available for use in Canada - fixed copper.

Using Fungicides

In order to be effective the fungicide should be on the plant during the infection period of the fungi.

The frequency of applications needed varies depending on the type of fungus and the weather. If the fungus has a short life cycle and there are good conditions for the growth of the fungus, it can have many infection periods and many applications may be needed. If conditions are poor for its growth, few applications may be needed.

Frequency of applications can also be affected by rain, speed of plant growth, and type of fungicide. Applications may need to be repeated if the fungicide is washed off by rain, if new leaves grow, or if the fungicide breaks down quickly.

Quiz 10.3 - Diseases

1. **What are two reasons why it is important to know if a plant is suffering from a disease caused by environmental stress?**

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2. **What are three types of living organisms that cause disease?**

    ____

    ____

3. **What are four steps that will help identify a disease?**

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4. Why is it difficult to control a fungus after it is inside the plant (the infection stage)?

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5. How does monitoring weather conditions help control some diseases?

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6. Give an example of each of the four non-chemical control methods for diseases.

a. Sanitary-____

____

b. Cultural-____

____

c. Mechanical-____

____

d. Biological-____

____

7. What is the main difference between protectant and eradicant fungicides? Which is more effective and why?

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8. Which of the following is not likely to affect the number of fungicide applications needed in a season? (Circle your answer.)

a) length of the fungus life cycle
b) conditions for fungus growth
c) conditions for new plant growth
d) soil type and pH
e) type of fungicide used
f) rain

Check your answers against the Quiz Answer Key at the back of this lesson; then continue on to the following section.

Weeds and Weed Control

Weeds are plants growing where they are unwanted. A plant which may be wanted in one location can be a weed in another - for example, volunteer potatoes would be a weed when growing in a crop of cabbage. (A volunteer is a crop plant growing where it is not intended.)

Types of Weeds

Weeds are usually classified according to how long they live.

a) Annual weeds complete their life cycle within one year. Most annuals produce many seeds to ensure their survival. Annuals can be divided into two groups: summer annuals, which germinate in the spring, and winter annuals, which germinate in the fall.

Examples of summer annuals: pigweed, lamb's-quarter, and barnyard grass.

Examples of winter annuals: shepherd's purse, chickweed, and henbit.

b) Biennial weeds live more than one year but less than two years. They grow from seed which usually germinates in the spring. The first year they store food, normally in short fleshy roots. Usually the foliage consists only of a rosette of leaves. In the next season the plant uses the stored food and grows vigorously. It produces seed in the summer or fall and then dies.

Examples: common burdock, bull thistle, and wild carrot.

c) Perennial weeds are plants that live more than two years. Often no seed is produced the first year; thereafter, seeds can occur every year for the life of the plant. Almost all perennial weeds spread by seed. Some spread by other plant parts such as creeping stems, creeping roots, rhizomes (a root-like underground stem), underground bulbs, or a broken piece of root.

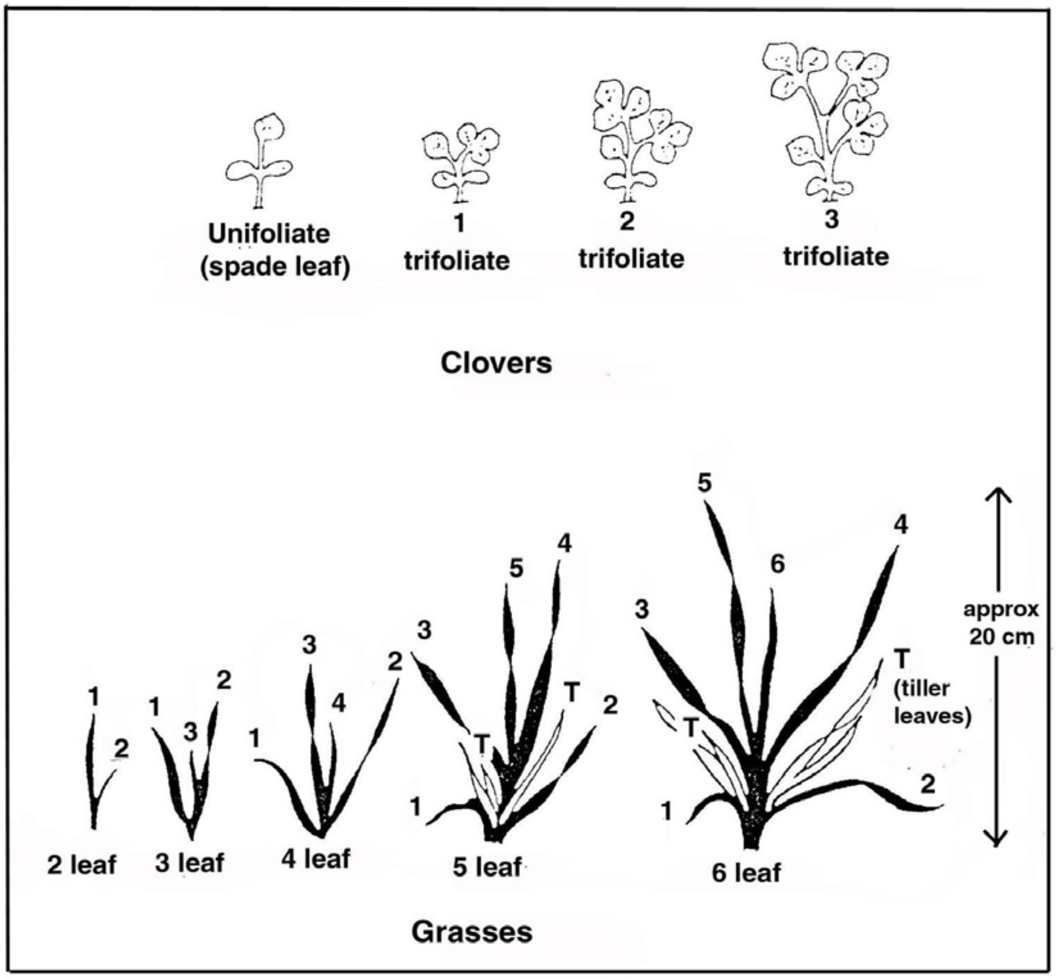
Examples: dandelion, quackgrass, and Canada thistle.

Identifying Seedling Leaf Stages

Herbicide labels refer to weed and crop leaf stages.

Example: the Poast label says it must be applied between the two to five leaf stage of barnyard grass for the best control.

It is important to remember that weed sizes and leaf numbers can change rapidly. To avoid applying herbicides past the stage when they will be effective, walk your fields regularly to monitor weed and crop growth.



Leaf Stages of Broadleaf Plants

When counting leaves you must be able to distinguish cotyledons from true leaves. Cotyledons are not counted when determining leaf number. Cotyledons are the seed leaves which are normally the first to appear. They are usually a different shape than the true leaves and may dry up and disappear at an early stage. On a few plants (fababeans, lentils, and peas) they stay below the soil surface.

When counting leaf numbers, count each true leaf whether alternate, opposite, or in a whorl, unless the recommendation refers to the number of whorls. As their names suggest, alternate leaves emerge from alternate sides of the stem and opposite leaves are pairs of leaves coming from the same node on the stem. As shown in the preceding diagram, whorls are groups of three or more leaves coming from the same node on the stem.

Leaf Stages of Annual Grassy Plants

Count all the leaves on the main shoot. A leaf should be counted as soon as it emerges. Do not include tillers in a leaf count. Tillers (or stools) are the secondary shoots of a grass plant which emerge from the base of leaves, generally at the three to five leaf stage.

Leaf Stages of Alfalfa and Clover

Alfalfa and clover have compound leaves made up of several leaflets (small leaves). As shown in the preceding diagram, each compound leaf (group of leaflets) is counted as one leaf. Do not count each leaflet.

Weed Management Methods

There are many weed control methods. Using a combination of several methods usually improves weed control.

1. Sanitary control emphasizes preventative measures, including:

- **using clean certified seeds (no weed seeds);**
- **controlling weeds on nearby ditches, fencelines, roads, etc.;**
- **cleaning machinery before moving it between fields and farms;**
- **hosing or brushing the hair and feet of animals before moving them to a new area;**
- **using only well-rotted manures - storage should generally be four to five months so that weed seeds which survive digestion will rot.**

2. Cultural control emphasizes competition to discourage weeds, including:

- **nurse or companion crop - a fast-growing crop such as a cereal planted along with a slower-growing one such as fine grasses. The fast crop competes strongly with weeds and is mowed when the slow one is well established.**
- **increasing a crop's ability to compete against weeds by using good farming practices - optimum fertilizer rates, etc.**

3. Mechanical control disrupts weeds and can include:

- **cutting weedy crops prior to weed seed production;**
- **tillage and hand weeding;**
- **mowing;**
- **burning;**
- **using mulch to suppress seed germination.**

4. Biological control can include both traditional and newer techniques such as:

- **grazing a field prior to weeds going to seed;**
- **using grazers such as geese and sheep to suppress weeds in orchards;**
- **releasing pest-specific insects - these have been released in areas of British Columbia, Prince Edward Island and Nova Scotia where certain weeds have become a problem.**

Examples: ***a type of root-feeding beetle and several species of seedhead flies have been released to control knapweed, while another root-feeding beetle species and a moth species have been introduced to control tansy ragwort.***

5. Chemical control is the use of herbicides to control weeds.

Types of Herbicides

Herbicides are classified according to:

a) selectivity
b) mode of action
c) timing of application
d) residual effectiveness

Selectivity

A selective herbicide will only kill certain plants. A non-selective herbicide kills or damages all plants in a treated area.

Examples: ***2,4-D is a selective herbicide that will control only broad-leaved weeds but will not affect surrounding grasses. Roundup is a non-selective herbicide that will kill most plants it contacts.***

Mode of Action

How the herbicide kills a weed is called its "mode of action."

- **Contact herbicides kill plant parts contacted by the herbicide. There is little or no movement of the herbicide in the plant. Contact herbicides are effective against annual weeds but they only "burn off" the tops of perennial weeds.**

Examples: ***contact herbicides may be selective such as Torch (bromoxynil), which kills broad-leaved weeds in cereals without damaging the crop, or non-selective such as Gramoxone (paraquat), which kills any green plant material the spray contacts.***

- **Systemic herbicides enter the roots or above ground parts of plants. These herbicides move or are translocated in the plant. Effects may not show for a week or more after treatment. Too much on the leaves may kill the leaf cells too quickly and prevent translocation to the site of action in a plant.**

Examples: ***systemic herbicides can be selective as in the case of 2,4-D, MCPA, Banvel, and Tordon, or non-selective like Roundup.***

Timing of Application

Herbicides are applied at different stages of crop or weed growth.

- **Pre-plant - The herbicide is applied to the soil before seeding or transplanting. Pre-plant treatments are usually incorporated or mixed into the soil. These are called pre-plant soil-incorporated treatments (e.g., Surpass, Treflan).**

- **Pre-emergence - The herbicide is applied to the soil after planting but before emergence of the specified crop or weed. "Preemergence" may refer to the germination (emergence) of either the weed or the crop; see the label for instructions as to whether it is pre-crop, pre-weed or both (e.g., Dual).**

- **Post-emergence - The herbicide is applied after the specified crop or weed has emerged. The application may be "early" (i.e., soon after emergence) or up to a specific height or leaf stage.**

It is extremely important to apply the product at the correct stage of crop and weed growth as described above. If a mistake is made identifying the stage, or if label instructions aren't followed, the crop may be damaged or weed control may be less effective.

Residual Effectiveness

Herbicides can be either non-residual or residual.

Non-residual herbicides are quickly made inactive in the soil after application and do not affect future crops (e.g., Roundup).

Residual herbicides do not break down quickly and may control weeds for several weeks to several years (e.g., Surpass, atrazine). Unfortunately, residual herbicides can also affect the growth of future crops. Rotating crops may be the only way to avoid crop damage from previous residual herbicides.

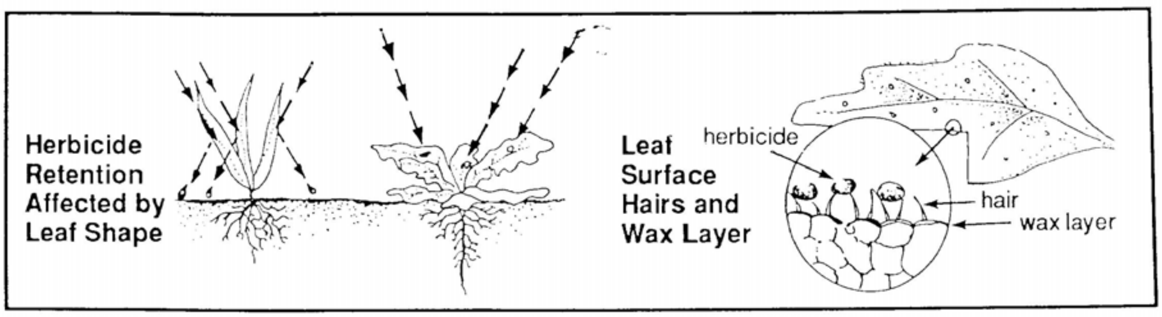
Soil sterilants are non-selective residual herbicides which are applied to soil to prevent growth of plants for a long period of time. They can prevent plant growth for a few months or for a number of years depending on their residual effectiveness.

Examples: ***bromacil, tebuthiuron, and high rates of atrazine.***

Factors Affecting Herbicide Effectiveness

Many factors can affect the success of a herbicide application. These include:

a) Shape and surface of the weed leaf. Thin upright leaves are hard to cover with spray. Hairy or waxy plant surfaces may reduce the herbicide contact. Surfactants (or surface active agents) can be added to herbicide formulations to increase the wetting ability of the spray so it won't bead, or to cut through waxy surfaces and aid



penetration into the leaf. They should be added only if the herbicide label says so.

b) Weather. Temperature, humidity, rain, and wind may affect herbicide effectiveness. Moderate conditions are usually better than extremes. The herbicide label will indicate what weather conditions should be avoided.

Cool or dry conditions slow the production and movement of food in the plant and reduce the movement of systemic herbicides. Hot, dry weather may make the herbicide evaporate quickly from the weed leaves and therefore reduce effectiveness.

Rain during or after an application can wash the herbicide off the plants. However, some soil-applied herbicides require irrigation or rain after application.

Wind can cause drift and prevent the herbicide from reaching the target.

c) Age of the weed. Herbicides are often more effective on young, rapidly-growing weeds. Systemic herbicides, which move with the food and water, can spread faster in rapidly-growing younger weeds than in older plants. Herbicides are less likely to kill plants which are in full flower or producing seed.

Perennial weeds often become more resistant to herbicides as they grow older, but may become more susceptible again in the bud or early flowering stages. This is because their roots or spreading rhizomes must be killed and, at these stages, herbicides will move into the roots or rhizomes along with the food supply the weeds are storing there.

d) Nutrition. Herbicides work best when the weeds are growing vigorously. Soil nutrients are needed for good weed growth.

e) Soil type. More herbicide may be needed for organic (peat or muck) or fine textured soils (clay or silt). These soils hold more herbicide on the soil particles and this reduces the amount available for weed control. Sandy soils usually need less herbicide. The herbicide label will tell you how much is needed. Never use more than the label rate.

f) Soil moisture. Soil-applied herbicides generally work best in a warm, moist soil. The moisture helps the herbicide move to the weeds.

g) Cultivation. Cultivating before a herbicide application can make herbicides more or less effective depending on the weed and the herbicide. Some weeds may be weakened by cultivation and become easier to control while other weeds may be broken into pieces and be harder to control. Read label directions before cultivating to see if it will be beneficial.

The "stale seedbed technique" is to cultivate unseeded soil so that weed seeds are encouraged to germinate. When they appear they are sprayed with a non-selective herbicide. The crop can then be planted.

h) Resistance. There have been increased reports of weeds developing resistance to pesticides.

Quiz 10.4 - Weeds

1. What are the three types of weeds and how long does each type live?

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2. Briefly describe "tillers" and "cotyledons." Are they counted as leaves?

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3. Give an example of each of the four non-chemical control methods for weeds.

a. Sanitary- ____

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b. Cultural- ____

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c. Mechanical- ____

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d. Biological- ____

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4. What is the risk in using a non-selective herbicide rather than a selective one?

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5. Why are contact herbicides less effective against perennial weeds?

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6. What is the difference in meaning between "pre-plant," "pre-emergence," and "post-emergence"?

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7. Residual herbicides may control weeds for several years after being applied, but they have a major disadvantage. What is it?

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8. What are six factors that can affect the success of a herbicide application?

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Check your answers in the Quiz Answer Key at the back of this lesson, then continue on to the following page.

In Conclusion

A Word About Other Pests

This material has focussed on general principles and on three main types of pests; insects, diseases, and weeds.

There are many other types of pests such as nematodes, snails, slugs, rodents, birds, and algae. You can successfully apply the general principles of pest management and application safety to them all.

Knowing and Doing

This course has covered only the basics - the minimum for safety. There's much more to learn for truly effective pest management. Continue to add to your knowledge of pests, of the many available control methods, and of safe application techniques.

Improving your skills in cost-effective pest management techniques will mean improved profit. In addition, it's in your best interest to ensure that any pesticide usage is safe for you, your consumers, and your environment.

And remember . . . knowing is not enough. You have to do it to get results.

Goldilocks said to Poppa Bear "There, that wasn't so hard after all,was it?"

Poppa Bear put down his pencil and paper and stared out the window. "Things sure keep changing, don't they? Reminds me of that joke about having to run just to stay in one place. Guess I've got to keep changing too if I want to stay in this business."

Suddenly he noticed a fly crawling towards some crumbs on the table. "I've just monitored one more fly than I can tolerate," he said. Swiftly he swept up the crumbs. "Sanitary control!" he announced. He closed the window screen. "Mechanical control!" he proclaimed. "Now, if there were time I'd go find a frog for biological control, but as there isn't . . ." and he reached towards a yellow spray can.

"Not chemical control!" said Momma Bear. "We haven't tried all the other methods yet."

"Oh, right!" said Poppa Bear. He picked up a poetry book Baby Bear had been reading and triumphantly smashed it down on the offending fly.

"There!" he said proudly. "Cultural control!"

The End (finally)

A Checklist

Here is a checklist of things to think about. It is not for the exam, although it might help you review what you've learned. Use it to review your own procedures from time to time.

Before you find pests:

- **Have you taken all possible measures to prevent pest problems?**
- **Do you regularly inspect your crops for pests?**

When you find a pest:

- **Have you confirmed its identification?**
- **At what stage of its life cycle is the pest best controlled?**
- **Is the pest population at a level where it should be controlled?**

Choosing a control program:

- **What control methods are available for this pest?**
- **Which methods are most effective?**
- **How toxic are the control methods to people?**
- **Could nearby non-target organisms be harmed?**
- **Could environmental damage occur?**
- **Will the control program minimize the development of pesticide resistance?**

If you're going to use a pesticide:

- **Does the pesticide fit with your harvesting or grazing plans?**
- **Will it affect your crop rotation plans?**
- **Can you leave buffer zones around sensitive areas such as wells, streams, and adjacent crops?**
- **Can you keep fieldworkers and bystanders away from the area to be treated?**
- **Do you have suitable application equipment?**
- **Do you have appropriate, clean, protective equipment?**

Before you apply the pesticide:

- **Have you read the label for details on application, poisoning symptoms, first aid, and safety requirements?**
- **Is the application equipment in good working order?**
- **Has it been accurately calibrated recently?**
- **Have you accurately calculated the amount of pesticide and spray mixture needed?**
- **Are weather conditions suitable for application?**
- **Is an adjuvant required? If so, is it registered for use with this pesticide?**
- **Have you informed farm workers to remain out of the area?**

After application:

- **Has the treated area been posted?**
- **Is the mixing area clean and tidy?**
- **Are the pesticides stored properly?**
- **Has the protective equipment been cleaned and stored?**
- **Have empty containers been properly rinsed and disposed of?**
- **Have you recorded information about the pest, the weather, and results of the application?**

Answer Key

Quiz 10.1 - General

1. What is "monitoring" and why is it done?

Monitoring is watching pest levels and growth stages, and possibly noting weather conditions favorable for them. It helps determine if pesticide treatment is really needed and is useful when scheduling the most effective treatment time.

2. Why should you be able to accurately identify a pest? Give two reasons.

To choose the right control method for that pest.
To prevent accidental killing of beneficial organisms.

3. Why is it important to be able to identify the stages of a pest?

Some stages are more easily and effectively controlled than others. (And it may help in making a more accurate identification of the pest.)

4. List the five categories of pest control methods used in this lesson and very briefly define each one:

Sanitary - not giving pests a place to breed or a way to spread
Cultural - growing crops in a way to discourage the pest
Mechanical - using things which keep out, kill, disrupt, or capture pests
Biological - using beneficial organisms (natural predators, parasites, and diseases of pests) to keep pests at manageable levels
Chemical - applying pesticides

5. What is a "beneficial organism"?

An organism which helps control a pest because it is a natural predator, parasite, or disease of the pest.

6. List three reasons why pesticides should be used only when necessary.

To minimize (any three of):

risks to the applicator and fieldworker
development of pest resistance to pesticides
damage to beneficial organisms
pesticide residue on food crops
risks to the environment

7. What does it mean when a pesticide has a "residual effect"?

It will remain effective for some time after it is applied.

8. What is the difference between a "selective" pesticide and a "non-selective" one?

A selective pesticide affects only certain pests. A non-selective pesticide can affect many living things.

9. List three ways to help prevent the development of pest resistance.

using a variety of control methods, especially non-chemical;
only using pesticides when needed;
alternating pesticides from different chemical groups.

10. What is the "economic threshold"?

The point where the possible cost (loss or damage) from an untreated pest is significantly greater than the total costs of treating the pest.

11. In addition to the economic threshold, what other factor should be considered when making a decision to apply controls?

the personal and environmental risks of application

12. What are two reasons for keeping records of pests, controls used, etc.?

Any two of:

To help evaluate what worked and what didn't.
To plan crop rotation, and to avoid problems with residual pesticides.
To notice the development of pest resistance.

13. **What is the main idea of integrated pest management?**

    Bringing together monitoring, a knowledge of pest biology, and use of all available control methods in order to create a program which is as cost-effective and environmentally safe as possible.

Quiz 10.2 - Insects and Mites

1. **At which stage is control usually best on insects or mites?**

    b) juvenile (young, nymph, or larva)

2. **Give an example of each of the four non-chemical control methods for insects.**

    a. Sanitary - destroying debris, steam-sterilizing soil, cleaning containers and equipment, controlling nearby food sources
    b. Cultural - rotating crops to break insect life cycles; adjusting planting and harvesting times in relation to the insect's life cycle
    c. Mechanical - screening openings; using traps; mowing or otherwise physically disrupting the insect's environment
    d. Biological - releasing sterile insects, parasitic wasps, predatory mites, and predatory insects such as ladybird beetles, lacewings, and hover flies; utilizing microbacterial insecticides such as B.t. (Dipel)

3. **What is the difference between contact and systemic insecticides?**

    Contact insecticides injure the insect by coming directly into contact with it. They are sprayed on it or on something it walks on or eats.
    Systemic insecticides enter the insect's food - plant or animal and travel to where the insect may suck it.

4. **List three other types of insecticides and briefly mention how they work.**

    Suffocating insecticides - clog breathing systems
    Growth regulators - interfere with normal growth and development
    Microbials - are tiny bacteria which kill insects when eaten

Quiz 10.3 - Diseases

1. **What are two reasons why it is important to know if a plant is suffering from a disease caused by environmental stress?**

   So you don't mistake the symptoms for a disease caused by living organisms and wrongly try to treat it instead of the stress.
   A stressed plant is more susceptible to infectious diseases.

2. **What are three types of living organisms that cause disease?**

   fungi; bacteria; viruses

3. **What are four steps that will help identify a disease?**

   Look for patterns of abnormal growth.
   Look for disease structures.
   Examine the surrounding area to see how and where it is spreading.
   Compare symptoms to those of diseases to which the crop variety is susceptible.

4. **Why is it difficult to control a fungus after it is inside the plant (the infection stage)?**

   It is protected by being inside the plant.

5. **How does monitoring weather conditions help control some diseases?**

   It can forecast when conditions are likely to be favorable for the spread and development of the disease. Treatment can be applied only when necessary, and at the most effective time.

6. Give an example of each of the four non-chemical control methods for diseases.

a. **Sanitary - cleaning bins and equipment; using certified seeds or disease-free plants; quarantining; using hot-water-treated seeds or bulbs; sterilizing soils with heat; cleaning up trash that could host diseases; controlling vectors**

b. **Cultural - using disease-resistant strains; changing the environment to discourage diseases; rotating crops; encouraging strong plant growth**

c. **Mechanical - removing and destroying diseased parts**

d. **Biological - using biological control agents where available**

7. What is the main difference between protectant and eradicant fungicides? Which is more effective and why?

A protectant is a film outside the plant which prevents the spores from germinating and infecting the plant, whereas an eradicant attempts to control the fungus after it has infected and entered the plant.

A protectant is the most effective method because the fungus has not done damage yet and is at its most vulnerable stage.

8. Which of the following is not likely to affect the number of fungicide applications needed in a season?

d) **soil type and pH (all the others are likely to affect it)**

Quiz 10.4 - Weeds

1. What are the three types of weeds and how long does each type live?

annual - a year or less
biennial - more than one year but less than two
perennial - more than two years

2. **Briefly describe "tillers" and "cotyledons." Are they counted as leaves?**

   Tillers (or stools) are secondary shoots of a grass plant that emerge from the base, usually at the three to five leaf stage. They are not counted.

   Cotyledons are the seed leaves; they often have a different shape than true leaves. They are not counted.

3. **Give an example of each of the four non-chemical control methods for weeds.**

   a. **Sanitary - certified seed; controlling weeds on ditches, along roads, etc.; cleaning equipment and livestock; using well-rotted manure**
   b. **Cultural - nurse or companion crops; good farming, which helps crops grow strongly and compete against weeds**
   c. **Mechanical - tillage, hand weeding, mowing, burning, cutting before seeding, using mulches**
   d. **Biological - grazing; some biological control agents**

4. **What is the risk in using a non-selective herbicide rather than a selective one?**

   You could damage all other plants, including your crop.

5. **Why are contact herbicides less effective against perennial weeds?**

   They kill the tops, but not the roots which can then sprout new growth.

6. **What is the difference in meaning between "pre-plant", "pre-emergence", and "post-emergence"?**

   Pre-plant means before the crop seed has been planted.
   Pre-emergence means after the crop seed has been planted, but before the specified crop or weed has emerged above ground.
   Post-emergence means after the specified crop or weed has emerged above the ground.

7. **Residual herbicides may control weeds for several years after being applied, but they have a major disadvantage. What is it?**

   They may also affect future crops that you plant there.

8. What are six factors that can affect the success of a herbicide application?

Any six of:

<u>Shape and surface of the weed leaf - upright or flat? waxy or hairy?</u>
<u>Weather - rain, temperature, sunlight, wind.</u>
<u>Age of the weed - younger ones are usually easier to control.</u>
<u>Nutrition - herbicides work best when the weed is growing vigorously.</u>
<u>Soil type - some soils hold more herbicide, leaving less for the plant.</u>
<u>Soil moisture - warm, moist soils are best for uptake.</u>
<u>Cultivation - the effects vary depending on the weed.</u>
<u>Resistance - some weeds have developed resistance to herbicides.</u>