Volume
2

ATLANTIC CANADA PESTICIDE APPLICATOR TRAINING MANUAL SERIES

Landscape Training Manual

New Brunswick Environment and Local Government
Newfoundland & Labrador
Nova Scotia Environment and Labour
Prince Edward Island Canada

Cooperatively developed by the Atlantic Working Group for Pest Management Education and Training Standards

ATLANTIC CANADA PESTICIDE APPLICATOR TRAINING MANUAL SERIES

Landscape

This manual can be obtained from the following Provincial Agencies:

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The Atlantic Working Group is composed of representatives from the regulatory department that maintains responsibility for pesticide licensing/certification programs within each Atlantic Canada province. The mission of the AWG is to develop and maintain high quality pesticide education and training materials that meet or exceed the national *Standard for Pesticide Education, Training and Certification in Canada*. The development of this manual will promote consistency and harmonization of pesticide education, training, and licensing/certification programs, thereby allowing for greater reciprocity within Atlantic Canada.

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PREFACE

The basic knowledge requirements for pesticide application education in Canada consist of information covering the following topics:

General	Environment
Labelling	Emergency Response
Regulations	Pest Management
Human Health	Application
Safety	Public Relations

The *Applicator Core Training Manual* provides the basic information all applicators need to know about applying pesticides safely and effectively. There are 10 category specific modules that provide further information for applying pesticides in specific areas. The applicator core plus a specific module will provide full information for applying pesticides within a given area. The 10 specific areas are:

Aerial	Greenhouse
Agriculture	Industrial Vegetation
Aquatic	Landscape
Forestry	Mosquito and Biting Fly
Fumigation	Structural

To obtain a licence or certificate in pesticide application you must write a pesticide applicator exam. This exam consists of information found in the *Applicator Core Training Manual* as well as a specific category manual. **NOTE: For agricultural applicators, the applicator core and agriculture category exams have been combined.**

The following manuals are currently available in Prince Edward Island from the PEI Pesticide Regulatory Program at (902) 368-5474 or pesticideinfo@gov.pe.ca

Volume 1 *Applicator Core Training Manual*
Volume 2 *Landscape Training Manual*
Volume 3 *Agriculture Training Manual*
Volume 4 *Biting Fly Training Manual*
Volume 5 *National Aerial Training Manual*

DISCLAIMER

The information in this manual is supplied with the understanding that no discrimination is intended, and that listing of commercial products implies no endorsement by the authors or the Prince Edward Island Department of Environment, Energy and Forestry.

Due to changes to laws and regulations that occur over time, the Prince Edward Island Department of Environment, Energy and Forestry assumes no liability for the suggested use of pesticides contained herein.

No pesticide can be used unless it is registered in Canada for the intended use and has a *Pest Control Products Act* registration number. At all times, pesticides must be applied according to the label directions on the pesticide container.

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Chapter 1

GENERAL INFORMATION

Pesticides can be grouped in a number of ways; by mode of action, by target pest or by chemical family. The **General Information** chapter in the **Applicator Core Manual** gives additional information on grouping by target pest and mode of action.

Pesticides are often complex chemical formulations. They are built around a number of core chemical structures or building blocks. Chemists have grouped these core structures into chemical families. Pesticides in the same chemical family often have similar properties (e.g., poisoning symptoms, persistence in the environment). Knowing the chemical family provides an idea of the health and environmental risks. This helps you to make sound decisions and choose the least hazardous pesticide. Knowing the family also helps you to choose the proper personal protective equipment and identify needed safeguards to protect the environment.

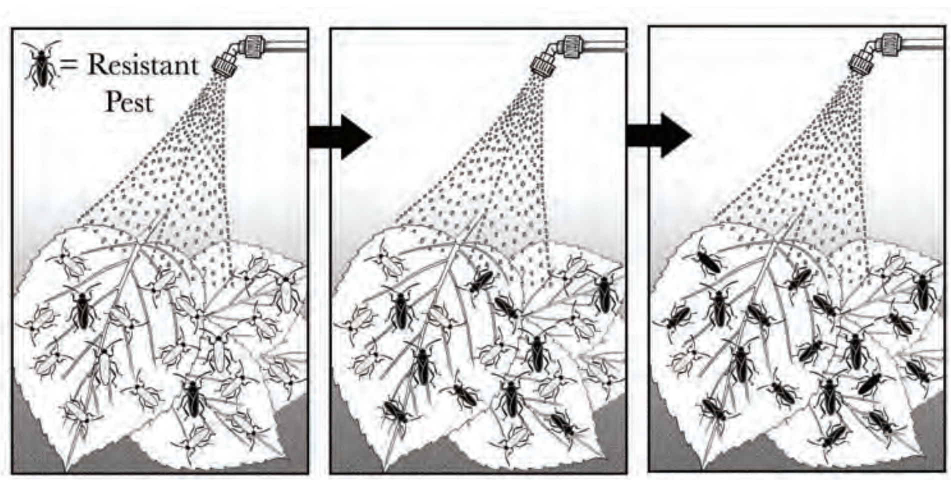


Figure 1-1: Pest resistance increases with repeated exposure to products from the same chemical family.

Pesticides in the same family are likely to control pests in the same way. Repeated use of pesticides that control pests in the same way increases the risk of pesticide resistance. For example, repeated use of an insecticide in one chemical family can speed insect resistance to other insecticides in the same family. Using pesticides from more than one chemical family reduces risk of pesticide resistance developing. This extends the useful life of each product. When pesticides are used in an Integrated Pest Management (IPM) program, care is taken to alternate pesticides of different chemical families.

Pesticide applicators must know which chemical family a given pesticide belongs to. This chapter looks at how a number of chemical families of pesticides are used in the landscape industry.

Learning Objectives

Completing this chapter will help you to:

- **Know the properties of chemical families used in the landscape industry**
- **Make informed choices to manage health and environmental risks.**

Chemical Families

Most pesticide active ingredients are either inorganic or organic carbon-based. Inorganic pesticides do not contain carbon and are often derived from mineral ores (copper, sulphur) or their salts (e.g., copper sulphate, sodium chlorate, ferrous sulphate). Most pesticides that have carbon in their chemical structure are made from petroleum-based compounds. Pesticides made from plants are called "botanicals" or "botanical pesticides".

Organic carbon-based pesticides are grouped into families with similar molecular structures. Products in the same chemical family often have similar first aid, clean-up, and safe handling procedures. Pesticides within a group often have similar properties and modes of action in controlling pests.

The most common pesticide groups used for pest control in the landscape industry are given in **Tables 1-1**., **1- 2 and 1-3.**

Herbicides

Table 1-1: List of herbicides within the various chemical families.

Chemical Family	*Common Name*
Benzoic Acid	dicamba
Bipyridylium	diquat, paraquat
Piclorinic Acid	triclopyr, picloram
Phenoxy	2,4-D, 2,4-DB 2,4-D + diclorprop, MCPA, MCPB + MCPA
Thiocarbamates (Carbamates)	triallate, EPTAC, butylate
Triazines	atrazine, metribuzin, hexazinone, simazine
Ureas	linuron, diuron, tebuthiuron
Miscellaneaous	glyphosate, difenzoquat

Insecticides

Table 1-2: List of insecticides within the various chemical families.

Chemical Family	*Common Name*
Carbamates	aldicarb, carbaryl, methomyl, pirimicarb
Petroleum-based products	dormant oils
Organophoshates	azinphos-methyl, diazinon, dimethoate, malathion, methamidaphos, methidathion, trichlorfon
Organochlorines	chlorpyrifos, endosulfan
Pyrethroids	cypermethrin, deltamethrin, permethrin

Fungicides

Table 1-3: List of fungicides within the various chemical families.

Chemical Family	*Common Name*
Dithiocarbamates (Carbamates)	maneb, mancozeb, thiophanate-methyl, metiram, propamocarb, chlorothalonil, thiram
Dicarboximides	iprodione and vinclozolin.
Benzimidazoles	benomyl

Herbicide Families

Common herbicide families/groups used in the landscape include:

- **Synthetic Auxins -** These herbicides are plant growth regulators. They interfere with growth of new stems and leaves. This leads to twisting and malformation in target weeds. The synthetic auxins include:
    - **Phenoxy Herbicides -** Grass species are resistant to this group of herbicides. These selective herbicides are often used in turfgrass to

manage broadleaf weeds. This group includes 2,4-D, MCPA, and mecoprop. They have low to moderate toxicity.

- **Benzoic acid family -** This family includes dicamba. Dicamba is often used to control broadleaf weeds in turf. It is often combined with 2,4-D and MCPA.

- **Phosphate Synthesis Inhibitors -** This group of herbicides inhibits the synthesis of an enzyme in the phosphate production cycle. The herbicide glyphosate is included in this group. Glyphosate is used to control both broadleaf and grass weeds.

- **Bipyridylium Herbicides -** Bipyridylium herbicides are the most toxic herbicides used in landscape applications. They can irritate the skin and mucous membranes in the eyes, mouth, and lungs. Examples include diquat and paraquat.

Insecticide Families

Common insecticide families/groups used in the landscape include:

- **Organophosphates (OPs) -** Organophosphate insecticides act by inhibiting the cholinesterase enzyme. This enzyme is used in nerve function. A number of insecticides in this family are used to control a wide range of landscape insect pests. These products tend to have a short persistence in the soil. Common examples are listed in **Table 1-1**. These include phorate, malathion, diazinon, and dimethoate.

- **Carbamates -** The carbamate group includes insecticides, fungicides, and herbicides. Most have a short persistence in the environment. Like organophosphates, carbamate insecticides inhibit cholinesterase. Carbamates have moderate to high toxicity. Common examples include aldicarb, carbaryl, carbofuran, methomyl, and pirimicarb.

- **Petroleum-based Products -** Some petroleum-based products are registered as pesticides (e.g., dormant oils, summer oils). They act by suffocating pests.

- **Botanical Pesticides -** Botanical pesticides are used to control insects, spiders, and mites. They are rapidly degrading contact pesticides. Botanical pesticides (e.g. natural pyrethroids) are derived from plants. Pyrethrum is the most common of the natural pyrethroid group. Pyrethrum is extracted from the flower heads of the chrysanthemum plant. It is a mixture of four compounds with similar chemical structures. These compounds act by disrupting the nerve impulse as it travels down the nerve cell. If the nerve impulse is disrupted, muscles are quickly paralysed. The manufacturer often adds piperonyl butoxide to increase pesticide effectiveness. Pyrethrum is listed on pesticide product labels as the active ingredient "pyrethrins".

- **Synthetic Botanical Insecticides -** Synthetic pyrethroids (e.g., resmethrin and permethrin) are used as contact or stomach insecticides. They are man-made equivalents of natural pyrethrums. They show similar pesticidal characteristics. Piperonyl butoxide is often added to enhance effectiveness. Applications are made to foliage when pests appear.

- **Microbial Insecticides -** Microbial insecticides are insecticides that have been commercially developed from naturally-occurring microorganisms. Bt *(Bacillus thuringiensis)* is an example. These persticides only act on very specific groups of pests. Correct identification of the pest is necessary to obtain effective control.

Both natural pyrethrins and synthetic pyrethroids are toxic to fish and other aquatic organisms. Care should be taken not to apply these pesticides, or to clean application equipment near bodies of water.

Fungicide Families

Common fungicide families or groups used in the landscape include the following foliar sprays:

- **Dithiocarbamates -** Dithiocarbamate fungicides are non-selective, protectant fungicides. Examples include mancozeb, thiram and metiram (a non-systemic fungicide used for mildew and apple scab).

- **Dicarboximides -** Dicarboximide fungicides are protectants. These pesticides affect fungal cell division and disrupt fungus growth. Examples include iprodione and vinclozolin.

- **Benzimidazoles -** Benzimidazole fungicides are systemic fungicides. These fungicides inhibit tubulin formation (an essential part of fungal growth). Examples include benomyl, thiophanate methyl and thiabendazole.

- **Inorganic Fungicides -** Inorganic fungicides are non-selective, protectant fungicides. Examples include sulphur and copper.

Note: Terms such as protectant, non-selective, systemic and contact pesticides are defined in the **General Information chapter of the Applicator Core Manual.**

Chemical Additives

Common chemical additives found in pesticides used in the landscape industry include:

- Aromatic hydrocarbons
- Petroleum products and distillates
- Polymerized butanes (in sticky pastes)

These materials serve a number of functions. They can help make the pesticide more effective, extend its shelf life, or improve its handling. However, they can also make the formulated pesticide more toxic or flammable than the active ingredient is by itself.

Hazardous chemical additives found in the pesticide formulation are listed on the Material Safety Data Sheet. The label also gives information on any concerns related to chemical additives.

Summary

Pesticides are grouped into families according to chemical structure. Pesticides within the same chemical family often have similar properties. Knowing the chemical family of pesticides allows an applicator to make informed choices on protective clothing. It also allows you to decide what measures are needed to protect the environment. Alternating pesticides from different chemical families reduces the risk of pesticide resistance

Self-test Questions

Answers are provided in Appendix A of this manual.

1. Which chemical families of insecticides are cholinesterase inhibitors?

   ____

2. List two (2) common herbicides in the phenoxy herbicide family.

   ____

   ____

3. Which chemical family is derived from plants and what is the most common example?

   ____

4. What chemical is often added to pyrethrum to increase its effectiveness?

   ____

5. Both synthetic pyrethroids and natural pyrethrum are derived from flowers. **True or False**?

   ____

Chapter 2

HUMAN HEALTH

Pesticides are designed to kill or control pests like weeds, insects, fungi, or rodents. If not handled properly, pesticides can harm humans. Poor handling can result in exposure to the applicator, bystanders, food crops, non-target plants and the environment. Pesticide exposure can be dermal, oral, through inhalation, or through the eyes. Careful handling reduces risk. Always follow label directions and wear proper personal protective equipment (PPE). Pesticide applicators should know the toxicity of the chemical families of the pesticides they use.

Learning Objectives

Completing this chapter will help you to:

- **Know why individuals using pesticides should have medical examinations.**
- **Understand what cholinesterase is and how exposure to pesticides can affect it.**
- **Know when, how and how often to get a blood for cholinesterase.**
- **Know the general health effects of the pesticides used in the landscape industry.**
- **Know that over time, exposure to low doses of organophosphate and carbamate pesticides can affect the nervous system.**
- **Know that repeated exposures to organophosphate and carbamate pesticides can result in sudden poisoning.**
- **Know that exposure to organophosphate and carbamate pesticides may not be reversible.**

Before Working with Pesticides

Anyone planning to use pesticides should have a full medical examination. Explaining the nature and type of work to your physician will enable him/her to assess your "fitness" to work with pesticides. Individuals with certain medical conditions may not be able to work safely with pesticides: These include:

- Respiratory or heart disease that may preclude the use of respiratory protection
- Low levels of cholinesterase may preclude use of organophosphate or carbamate pesticides

Tell your employer/supervisor about any medical conditions that may make it unsafe for you to use pesticides.

Anyone using pesticides as part of their job should also have a regular medical examination.

Organophosphate and Carbamate Pesticides and Your Health

Organophosphate and carbamate pesticides are the most acutely toxic landscape pesticides. Pesticides in these families can affect the nervous system. They can inhibit the cholinesterase enzyme. Excessive exposure to these pesticides can reduce the work of this enzyme. This will cause acute poisoning symptoms.

Check the toxicological information on the secondary label panel and/or MSDSs of the pesticides you will be handling in the coming use season. Watch for a notice that states, "This product may cause cholinesterase inhibition". Follow the label recommendations for safe handling and personal protective equipment.

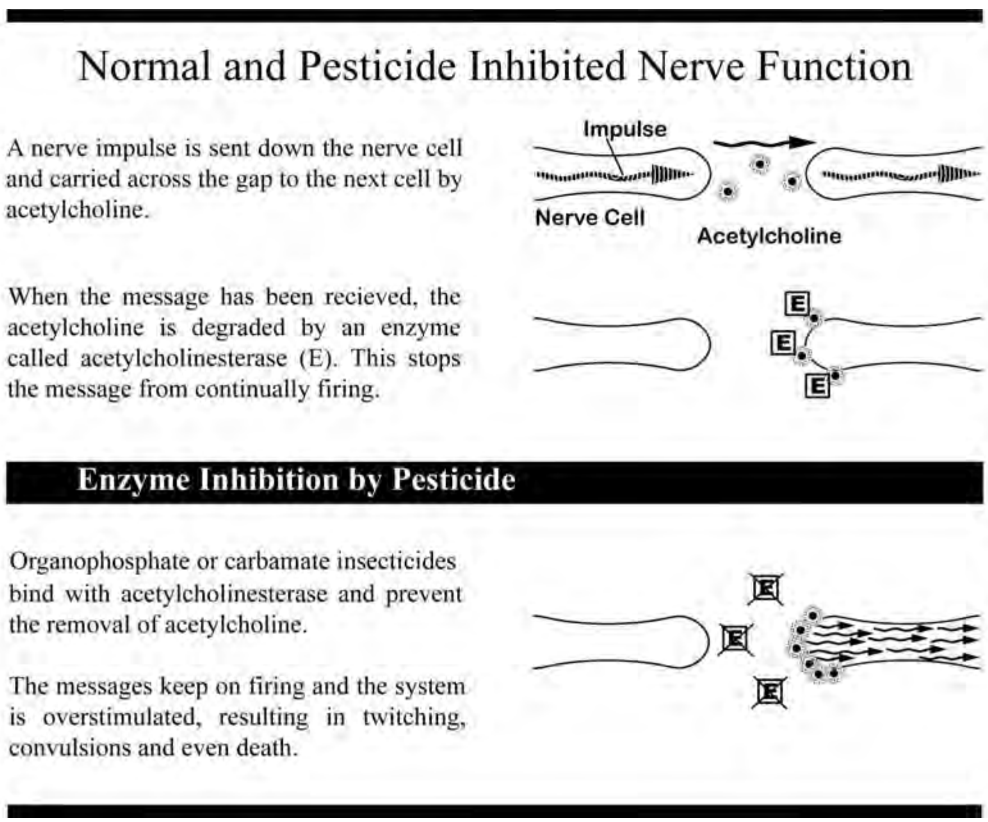
The Role of Cholinesterase

When a message moves through the nervous system, a signal must pass from one nerve cell to the next, across gaps. When the message reaches a gap, a chemical called acetylcholine is released. This chemical carries the message to the next nerve cell (***see* Figure 2-1**).

When the message arrives, cholinesterase breaks down the acetylcholine. This clears the gap and readies it for the next message. Organophosphate and carbamate insecticides bind with the cholinesterase and make it unavailable. When there is not enough cholinesterase, messages are sent to nerve cells over and over again. This causes muscles to twitch without stopping (tremors). If muscle action becomes intense, the victim may have seizures. The entire nervous system can be affected. Quick and proper medical care is needed for organophosphate poisoning.

Cholinesterase is an enzyme found in the blood. It allows the nervous system to control muscle movement. Organophosphate and carbamate pesticides may interfere with this enzyme.

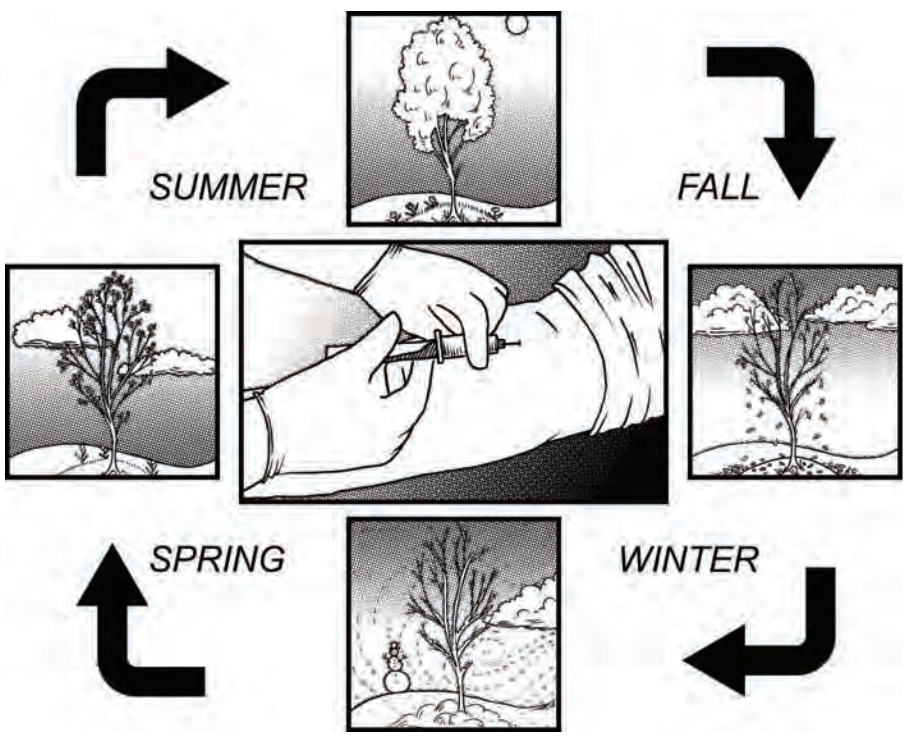
Figure 2-1: Normal and Inhibited Nerve Function.



Cholinesterase Blood Test

A blood test which measures level of cholinesterase in a person's blood may allow medical personnel to tell if a patient's symptoms are the result of organophosphate or carbamate poisoning. Each person has a different normal baseline value of cholinesterase. The blood test that is done at the beginning of the season before any pesticides are used gives the person's normal value for cholinesterase (e.g., the baseline). When exposure occurs, the cholinesterase level in the blood may be reduced. Exposure can result from not wearing or taking care of personal protective equipment and clothing. It can also result from not washing after handling these products. Contact a doctor to find out about this blood test.

Figure 2-2: Cholinesterase blood tests should be done at various times, to set baseline values, and determine if levels are acceptable.



Blood tests should be done at the start of the season before handling or using these pesticides. Blood tests should then be taken at regular intervals throughout the spray season. They should also be taken if poisoning is suspected. In order to be useful, cholinesterase testing must be done right after exposure. This can then be compared to a person's baseline value. Any changes should be noted. A medical professional who is familiar with pesticide exposure must then analyze these blood test results.

The medical professional who checks the results will advise further action if required. The test is effective for carbamates and organophosphates only.

Blood testing results may indicate a need to prevent further exposure. Without further exposure, blood cholinesterase will return to normal levels in about 120 days (in the case of organophosphate poisoning). This will be more rapid for carbamate poisoning.

Precautionary Steps

If cholinesterase inhibition is indicated on the pesticide label, consult medical personnel before the start of the season and arrange for blood tests. This will provide a personal baseline of cholinesterase activity for all applicators who will handle these pesticides.

Repeat blood tests at regular times throughout the spray season. Check this against the person's baseline value. A lower reading than this value may mean an exposure has occurred. The medical professional will advise if any required follow up action should be taken.

A person showing poisoning symptoms after handling carbamate or organophosphate pesticides should have the blood test repeated. This should then be checked against the baseline value.

In Review

Some pesticides used in the landscape industry are cholinesterase inhibitors. Those involved with handling pesticides need to check the secondary label panel of all pesticides. They should look for warnings such as: 'This product may cause cholinesterase inhibition'.

Every person has a different baseline value of cholinesterase. Workers are advised to have their blood tested for cholinesterase before handling pesticides. This test gives a person's baseline value. Blood tests taken later can be compared with this. A medical professional who is familiar with pesticide exposure must analyze the blood test results.

Follow-up blood tests can be done at any time in the use season. A blood test for cholinesterase should be performed if any symptoms of poisoning occur.

General Pesticide Effects on Human Health

Some pesticides used in the landscape industry are more toxic to humans than others. Pesticides in the organophosphate and carbamate chemical families require extra care. Workers in the landscape industry need to know the hazards of a single or repeated pesticide exposure. Knowing and using this information can minimize human health effects. Information on human toxicity for landscape industry pesticides is given below. **Table 2-1** shows some common ways that landscape applicators can be exposed.

Table 2-1: Some common ways in which landscape applicators can be exposed to pesticides.

Point of Exposure	*Common Ways of Being Exposed*
Dermal	Not washing hands after handling pesticides, containers, or equipment Splashing /spilling pesticide on skin Not wearing gloves when removing pesticide- contaminated personal protective equipment Applying pesticides in windy weather Not wearing gloves when touching treated plants or when handling spray equipment
Oral	Not washing hands before eating, smoking, or chewing gum Splashing pesticide into mouth Storing pesticide in anything but the original container
Inhalation	Handling pesticides in confined or poorly ventilated areas without wearing a respirator Handling dusts or powders without wearing a respirator Using an inadequate or poorly fitting respirator Being exposed to drift without wearing a respirator Not washing hands before smoking
Eye	Rubbing eyes or forehead with contaminated gloves or hands Splashing pesticide in eyes Pouring dry formulations without wearing goggles Applying pesticides in windy weather without wearing goggles

Acute Pesticide Poisoning Symptoms

Acute pesticide poisoning symptoms are described in the core. The following section describes how different groups of pesticides commonly used in the turf and landscape can affect human health.

Organophosphate Insecticides (OPs)

Many pesticides in this group are highly toxic to humans. They are quickly absorbed through the skin, lungs, or digestive tract. Even the least toxic of this group can cause poisoning.

Occasional mild exposure to these pesticides is not likely to produce toxic effects. However, repeated exposure to small doses of organophosphate insecticides is dangerous. These pesticides can affect humans and animals by interfering with an enzyme called **cholinesterase**. This enzyme is needed for proper nerve function.

Symptoms of poisoning can occur without warning if cholinesterase levels do not return to normal. There are often no serious long-term effects from small exposures, if exposure is then avoided until cholinesterase levels return to normal. If the exposure continues, there may be an irreversible inhibition of cholinesterase. This may cause either acute or long-term chronic health effects. This is a concern for workers in the landscape industry. Applicators may be exposed a number of times during routine handling of pesticides (see **Table 2-1**).

People who use organophosphate insecticides should have a blood test before each spray season. This gives a baseline cholinesterase level. Blood testing should be repeated at regular times during the season. This will detect any changes in blood cholinesterase levels. A decrease from the baseline level may show that exposure has occurred. This should be reported to the employer. Additional information on cholinesterase testing can be found later in this chapter.

Acute Poisoning Symptoms

Symptoms of acute poisoning from organophosphate insecticides may occur at once or within 12 hours after exposure. Workers should know the following symptoms, and should be able to recognize them in themselves or others:

Mild symptoms include:

- Loss of appetite
- Headache
- Dizziness
- Weakness
- Anxiety
- Tremors of the tongue and eyelids
- Contracted pupils
- Vision problems

Contact a doctor if any of these symptoms are noticed.
Moderate symptoms include:

- Nausea
- Salivation
- Stomach cramps
- Vomiting
- Sweating
- Slow pulse
- Muscle tremors

Severe symptoms include:

- Diarrhoea
- Pinpoint and non-reactive pupils
- Breathing trouble
- Pulmonary fluid build-up
- Bluing of skin
- Loss of bowel control
- Convulsions
- Coma
- Heart trouble

Medical care should be sought at once for those showing moderate to severe symptoms of poisoning.

Carbamates

Carbamates act in a similar way to organophosphates by inhibiting the cholinesterase enzyme. Unlike organophosphates, carbamates are quickly broken down in the body. Cholinesterase inhibition is brief. Unless special measures are taken, readings of blood cholinesterase in humans exposed to carbamates are often inaccurate and may appear normal. Symptoms of carbamate poisoning are similar to the symptoms of acute organophosphate pesticide poisoning (listed previously), but last for a shorter time.

Botanical Insecticides

Poisoning by botanical insecticides is rare. Botanical insecticides usually contain a low concentration of active ingredient. They have high LD_{50} values for mammals. Botanical insecticides may include many of the mild acute poisoning symptoms listed previously. An allergic-type reaction can occur from dermal exposure. An irritation of the throat and lungs (causing wheezing or coughing) can occur from inhalation.

Synthetic Botanical Insecticides

Poisoning by this group is rare. Synthetic botanical insecticides usually contain low concentrations of active ingredient. Like natural pyrethrins, synthetic pyrethroids have low to moderate acute toxicity to mammals. They have high LD_{50} values for mammals (e.g., Cymbush LD_{50} is 247 mg/kg body weight). These pesticides can irritate the skin and respiratory tract. Applicators should avoid breathing vapour or spray mist.

Phenoxy Herbicides

The acute toxicity of phenoxy herbicides can be low to moderate. Exposure to the solvent in the formulated product can produce ill effects. Some solvents are moderately irritating to the skin, eyes, respiratory tract, and gut lining.

Dithiocarbamate and Thiocarbamate Pesticides

This group has a low acute toxicity and does not inhibit cholinesterase. Some products in this group can irritate the skin, eyes, nose, throat, or lungs and must still be treated with caution. They can also cause nausea, vomiting, or muscle weakness (in very large doses).

Petroleum-Based Products

Petroleum distillates (e.g., kerosene, solvent distillate, diesel oil) are used as solvents, carriers and diluents in pesticide formulations or as a pesticide themselves (e.g. dormant oils).Two types of petroleum products are found in pesticides and may affect human health:

- Petroleum distillates
- Aromatic hydrocarbons

Petroleum Distillates

Petroleum distillates (e.g., kerosene, solvent distillate, diesel oil) are used as part of the pesticide formulation as a diluent or as a pesticide themselves. They have a wide range of toxicities. Symptoms of acute poisoning include:

- Nausea
- Vomiting
- Cough
- Lung irritation (This can cause bronchial pneumonia with fever and cough.)

If more than 1 mg of petroleum distillate for each kg body weight is ingested, central nervous system depression and irritation may occur. Symptoms include:

- Weakness
- Dizziness
- Slow and shallow breathing
- Unconsciousness
- Convulsions

Chronic or long-term poisoning can cause:

- Weakness
- Weight loss
- Anemia
- Nervousness
- Pains in the limbs
- Numbness

Aromatic Hydrocarbons

Aromatic hydrocarbons (e.g., xylene) are used as part of the pesticide formulation. They have a range of toxicities. Symptoms of acute poisoning include:

- Dizziness
- Euphoria
- Headache
- Nausea
- Vomiting
- Tightness in the chest
- Staggering

Severe symptoms include blurred vision, rapid breathing, paralysis, unconsciousness or convulsions. Even the least toxic of this group may poison humans if it is used improperly. Repeated exposure to small doses is also a hazard. Symptoms of acute poisoning may occur at once or within 12 hours of contact.

Summary

The risks and hazards from a single or repeated exposure to landscape pesticides will vary. All cases of exposure cause risk. Workers need to know the hazards. They must take all proper safety measures to reduce exposure including:

- Following label directions
- Wearing proper personal protective clothing
- Using good hygiene

People who work with landscape pesticides must guard against exposure and reduce risk. They must know the toxicity of the different chemical families of the pesticides being used. Symptoms may be mild, moderate, or severe. This depends on the amount of exposure and the pesticide's toxicity.

The more toxic organophosphate and carbamate families of pesticides are a toxicity concern. A single or repeated low dose may interfere with the cholinesterase enzyme. This enzyme regulates the flow of nerve signals to the muscles. This may cause serious poisoning.

Blood should be tested before handling cholinesterase inhibitors. This gives a baseline value. A medical professional may compare this value against later test results. This allows one to tell if there has been an exposure.

Self-test Questions

Answers are located in Appendix A of this manual.

1. Repeated exposure to small doses of an organophosphate insecticide is not very dangerous. **True or false**?

2. An applicator exposed to an organophosphate insecticide may show a decrease in cholinesterase enzyme level. **True or false**?

3. There are often no serious long-term effects from small exposures to organophosphate insecticides. This is as long as added exposure is avoided until cholinesterase levels return to normal. **True or false**?

4. Like organophosphate compounds, carbamates are broken down slowly in the body. **True or false**?

5. Weakness in muscles used for chewing and swallowing may be a symptom of exposure to which chemical family?

   ____

6. List the two (2) symptoms of acute poisoning from petroleum distillates.

   ____________________________ ____________________________

7. Exposure to organophosphate or carbamate pesticides can affect the nervous system by inhibiting the acetyl cholinesterase enzyme. **True or False**?

8. If organophosphate or carbamate insecticides are present in the body, there will not be enough cholinesterase to break down acetylcholine. List symptoms of poisoning that can occur when this happens.

   ____
   ____
   ____

9. Organophosphate or carbamate insecticides are going to be used. Explain why it is important to have a pre-season blood test for cholinesterase.

____

____

10. Phenoxy herbicides are cholinesterase inhibitors. **True or False**?

Chapter

3

PESTICIDE SAFETY

If not handled properly, pesticides can harm the applicator. Workers in turf and landscape industries must take steps to guard against exposure and reduce risk.

The use of personal protective equipment (PPE) will help protect pesticide applicators from pesticide hazards. The '**Pesticide Safety**' chapter in the **Applicator Core Manual** gives information on choosing, wearing, and looking after PPE. It also covers transporting, storing, mixing, handling, and disposing of pesticides. Turf and landscape pesticide applicators need to know how to properly choose and wear PPE for their type of work. This is described in the following sections.

Learning Objectives

Completing this chapter will help you to:

- **Understand the potential for exposure when handling pesticides in the turf care and landscape.**
- **Identify required personal protective equipment (PPE).**

Personal Protective Equipment

There are risks involved in using pesticides. Risk to the applicator increases when pesticides are used frequently or for long periods of time. In the turf care and landscape industries, there is a risk of long-term exposure (e.g., spray drift or contact with treated vegetation). Proper personal protective equipment (PPE) reduces the risk of acute and long-term health effects. Applicators must protect against exposure by using proper PPE. For example, feet and legs need to be protected to reduce exposure when applying pesticides while walking through the treatment area.

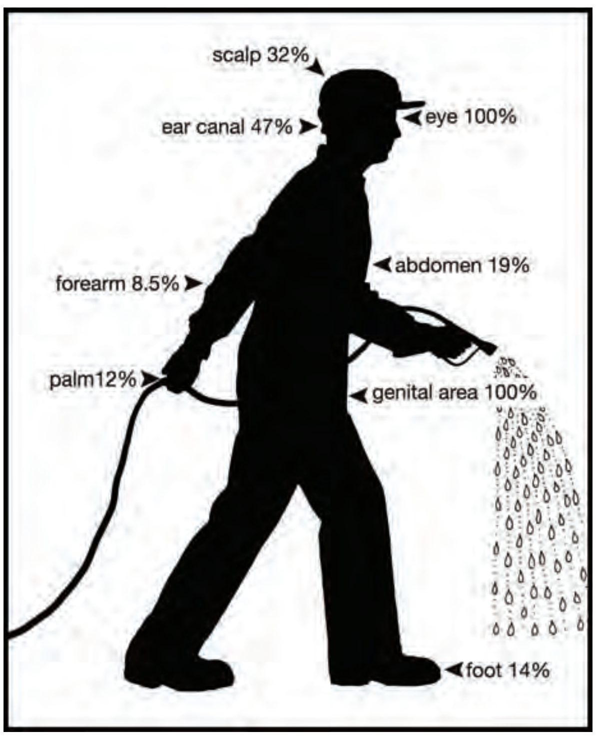


Figure 3-1: Absorption rates differ for pesticide exposure to different body parts.

Always read the label to see what PPE is needed for a given application. When working with pesticides, applicators must wear PPE, as stated by provincial law or the product label (whichever is stricter). The **Applicator Core Manual Chapter 5: Pesticide Safety** provides advice/guidelines on PPE.

When using backpack sprayers or spray wands for lawn treatments, applicators should at least wear:

- Long-legged pants
- A long-sleeved shirt
- Chemical resistant gloves
- Rubber boots

Personal protective equipment should be worn while handling, cleaning, and taking care of equipment. Check the label to see if a respirator, goggles or other additional PPE are needed when using specific pesticides.

Avoid spraying above shoulder height. This reduces applicator exposure. This will also protect others from drift. If an application above shoulder height is needed, additional PPE will be required. This may include:

- Full-face protection
- A respirator
- Long chemical resistant gloves
- Water repellant clothing
- Head cover

Figure 3-2: Applicators need more PPE to protect from overhead spraying.

Always wear PPE that is appropriate for the pesticide and method of application. If application equipment stops working properly, stop at once. Put on any additional needed PPE before cleaning equipment or making repairs.

When cleaning application equipment, (e.g., a plugged nozzle) wear:

- Chemical resistant gloves
- Rubber boots
- Coveralls
- Face protection

Applicators should know the risk of pesticide exposure when handling sods or grass clippings that have been recently treated with pesticides. Wear proper PPE including unlined gloves, coveralls, and boots. This will prevent contact with residues from recent applications.

Figure 3-3: Baseball caps can absorb pesticides and should not be worn when spraying.

Summary

If not handled properly, pesticides can harm the applicator. Workers in turf and landscape industries must take steps to guard against exposure and reduce risk.

Applicators should follow the guidelines outlined in the chapter 'Pesticide Safety' in the Core Manual.

Wear PPE that is appropriate for the pesticide and method of application. If application equipment stops working properly, stop at once. Put on any additional needed PPE before cleaning equipment or making repairs.

Self-Test Questions

Answers are in located in Appendix A of this manual.

1. What is the maximum safe height to apply pesticides (to minimize applicator exposure)?

   ____

2. List the PPE to be worn when cleaning plugged nozzles.

   ____

   ____

   ____

3. Ball caps should be worn to protect the head while spraying. **True or False**?

4. What PPE is **not** required (minimum) for applicators when handling, cleaning, and taking care of backpack sprayers or spray wands during lawn treatments?

   a. A respirator

   b. A long-sleeved shirt

   c. Chemical resistant gloves and rubber boots

   d. Long-legged pants

Chapter

4

ENVIRONMENT

Turf and landscape maintenance programs may include the application of pesticides in areas that are in close proximity to people, pets, sensitive plants, and wildlife. Pesticide applicators must always be aware of their surroundings. They must use care at all times to reduce non-target exposure and protect the environment. This chapter describes ways to protect important parts of the urban environment from pesticides.

Learning Objectives

Completing this chapter will help you to:

- **Know the impact that improper pesticide use can have on the environment, public, and pets.**
- **Know how to prevent contamination in an urban environment.**

Environmental Exposure

There is always a risk that landscape pesticide applications may affect the public, pets, sensitive plants, and the environment. People may walk into an area that is being treated. Children and pets may cross a newly treated playground. Pet dishes and toys may be accidentally exposed to pesticides.

During turf and landscape pesticide applications, care must be taken to avoid:

- Exposing people, pets and wildlife
- Pesticide runoff into storm sewers or open bodies of water
- Contaminating fishponds and pools
- Creating drift or leaching onto nearby properties
- Contaminating nesting birds and foraging bees when spraying trees
- Damaging sensitive plants and food gardens

General Guidelines for Protecting the Environment

To protect humans, pets, and the environment when working with pesticides:

- Develop integrated pest management (IPM) programs for the sites being managed.
- Follow all label directions.
- Use IPM principles.
- Avoid applications during nesting or feeding times for sensitive animal species.
- Select pesticides that reduce hazards to sensitive species (e.g., nesting birds, bees).
- Use equipment or spray methods that reduce drift (e.g., basal bark treatments, wipe-on or wick applicators for herbicides, low pressure settings, and coarse spray nozzles for sprayers). Reduce

spray pressure to increase droplet size. (Refer to **Nozzle Pressure** and **Spray Droplet Size** in **Chapter 7**.)

- Reduce the distance between the nozzles and the target.
- Add only approved drift control adjuvants or surfactants to the spray tank.
- Consider the site when choosing pesticides (e.g., granules for soil applications, sprays for foliar applications).
- Follow all provincial and municipal requirements (e.g., sign posting, permits, etc).
- Check wind speed and direction. Make sure conditions are within provincial and/or label wind speed guidelines.
- Do not apply volatile formulations such as ester formulations.
- Increase spray contact on the target by not spraying in high temperatures (especially with volatile pesticides). This also reduces the amount of pesticide that moves off-target through vapour drift.

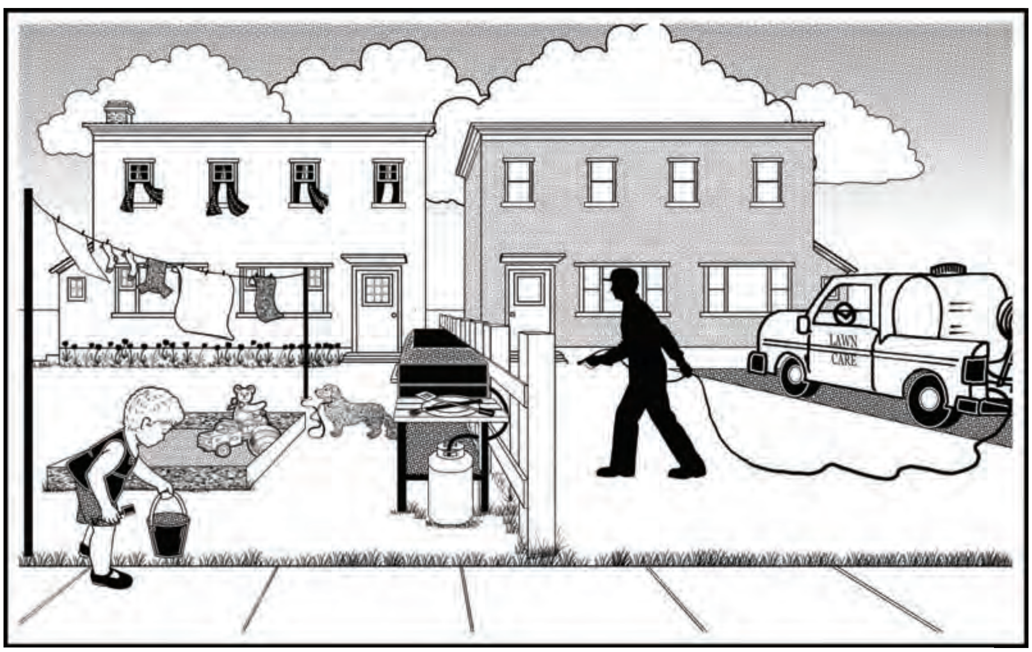


Figure 4-1: Notify nearby property owners before applying a pesticide so that they can keep children, pets, food and toys away from the area to be treated.

Guidelines to Protect Bystanders from Pesticides

Turf and landscape pesticide applications often take place in urban settings. This increases the risk of bystander exposure. Exposure can be direct (e.g., exposure to spray drift) or indirect (e.g., walking on recently treated turf). To reduce the risk of exposure, follow all provincial and municipal requirements. These may include requirements to:

- Notify the owners of nearby properties prior to a pesticide application. This allows nearby property owners to remove pets, pet dishes, children's toys etc., close windows and turn off air exchangers located near the treatment area if they wish.

- Post public areas with signs stating where and when treatments are planned, or have occurred.

- Use pesticides only during times of low public activity (e.g., weekends for school grounds, early morning for parks).

- Avoid spraying near public roadways when children or pedestrians are present.

- Tell owners or occupants of private land what to do to prevent exposure (e.g., avoid newly treated areas).

Guidelines to Prevent Contamination of Adjacent Land and Water Bodies

Water and land next to a property being treated should be protected from pesticide contamination. Contamination of water can occur as a direct or indirect result of runoff, leaching, or drift. Protect non-target areas near the application site by following the guidelines found in this chapter.

We all depend on clean drinking water. Water supplies must be protected from contamination. Prevention is key.

- Consult provincial or municipal regulatory bodies to find out the locations of municipal surface or groundwater supplies.

- Ask the property owner for the location of any private wells. Follow all set back requirements.

- Protect water bodies by mixing pesticides and washing equipment away from them.

- Leave an appropriate buffer between the treatment area and the water body. This reduces the risk of pesticide contamination. The buffer width may be governed by the label, or provincial authorities. The required buffer width may vary from site to site. It may depend on the slope of land, presence of vegetation, and type of soil. Fish-bearing waters must be protected. Refer to the **Applicator Core Manual - Environment** and **Applicator Core Manual - Pesticide Safety.** These chapters tell how to prevent surface and groundwater contamination and include information on buffer zones.

- For liquid formulations, water used to rinse containers should be put into the spray tank. This should be applied to the treatment area.

- Contact your proivincial regulator for guidance before disposing of mixed pesticide.

- Always direct spray inward from property lines. The risk of contaminating nearby properties is reduced by spraying away from them.

- Use no-spray setbacks to protect nearby properties. Where possible, ensure that any children's toys and pet food dishes located near the property line are moved prior to the pesticide application.

Guidelines to Protect Non-Target Vegetation from Herbicides

Tree roots often extend some distance from the tree. Care must be taken to prevent herbicides from being carried to the roots of trees and other non-target plants.

- Follow label directions that call for a buffer zone between the treatment area and non-target plants.

- If not stated on the label, herbicides should be applied no closer than one metre out from the drip line of trees. The drip line is the area on the ground that corresponds to the outer edge of the leaf canopy. This is where a tree tends to have many roots. Non-selective residual herbicides should be applied no closer than a distance that is twice the height of a tree (measured from the base of the trunk). Further distances or the use of shrouded sprayers may be required depending on:
    - Plant sensitivity to herbicides
    - Soil type
    - The herbicide used

Most ornamentals are sensitive to broadleaf herbicides. Extra care must be taken to prevent exposure to spray or drift.

Guidelines to Prevent Accidental Release of Pesticides

To prevent pesticides from being accidentally released:

- Keep spray equipment (power hoses, backpacks, tanks etc.) locked in vehicles or service truck compartments when not in use and during transport.

- Always be prepared to deal with pesticide spills and other emergencies. Have a pesticide spill kit, and emergency phone numbers on hand. Contact your provincial regulator to find out if an emergency response plan is also required.

- Never dispose of pesticide concentrates, empty containers, or excess spray mix on the client's property. Do not leave pesticides or containers behind for the client to dispose of.

Guidelines to Prevent Property Damage from Pesticides

Some pesticides can stain stucco, siding, wooden fences, or cement sidewalks. Check labels for precautions if there is a risk of spray landing on such surfaces. When in doubt, test the spray on a small area before applying it to the treatment area. Contact the provincial regulator for requirements (buffers or setbacks) when using pesticides near properties or occupied buildings.

Residual Activity

Residual activity is the length of time a pesticide remains in the environment. Use a pesticide with the least residual activity. **Table 4-1** lists herbicides registered for landscape use and their residual activity. **The use of herbicides with a long residual activity (e.g., "soil sterilants") is not covered under the Landscape Pesticide Applicators Certification. Contact your provincial regulator to find out if permits or additional certificates are required prior to using any of these products.**

Toxicity of Pesticides to Non-Target Plants

Pesticide injury to plants is called **phytotoxicity**. Phytotoxicity most often occurs when poor application of herbicides injures non-target plants. Insecticides, miticides, and fungicides may also injure the plants being protected. Phytotoxicity may occur when lawns are treated for broadleaf weed control without care to prevent exposure of sensitive ornamentals. Injury can be minor (e.g., slight burning or browning of leaves) or severe (e.g., death of the whole plant).

Possible reasons for phytotoxicity include the following:

- Pesticide sprays may drift through the air or move through the soil to sensitive plants near the treatment area.

- Pesticides may persist in soil. These can injure sensitive plants planted into the soil for some time after application.

- Improper pesticide dilution or using a too high application rate can cause plant injury.

- Incompatible mixtures of two pesticides or pesticides and fertilizers may damage plants. Consult the pesticide labels before tank mixing. When in doubt, contact your local pesticide vendor.

- Pesticide additives (e.g., emulsifiers) can make a pesticide phytotoxic to sensitive plants even at recommended application rates. Only add other materials to a spray mix if it is indicated on the pesticide label.

Table 4-1: Residual Activity of Some Herbicides Used in Landscape Situations.

Product Name	*Common Name*	*Notes On Residual Activity*
2,4-D	2,4-D	Rapid decomposition
Acclaim	Fenoxaprop-ethyl	None
Amiben	Chloramben	Six to eight weeks
Amitrole	Amitrole	Two to four weeks in warm, moist soil
Banvel	Dicamba	Thirty days, approximately
Basagran	Bentaxon	None
Basamid	Dazomet	Depends on rate, soil moisture, and temperature. Do a germination test to determine if soil is safe to plant in.
Betasan	Bensulide	Residual activity, one application gives season long control
Casoron	Dichlobenil	Persists two to six months, longer than one year for high rates
Compitox	Mecoprop	Up to four weeks. Grass can be seeded one to two weeks after application
Dacthal	Chlorthal-dimethyl	One hundred days, in most general soil types
Devrinol	Napropamide	Season long control for the growing season with incorporation
Gramoxone	Paraquat	None
Kerb	Propyzamide	Varies between two to nine months. Degradation increases with temperature above 15C
MCPA	MCPA	Some soil residue detected up to one month, if moist conditions, two months if dry
Poison-ivy and brush killer	Ammonium sulphamate	No longer than six to eight weeks
Reglone	Diquat	None
Round-up	Glyphosate	None
Simadex, Simazine, Princep Nine-T	Simazine	Persists more than one season, and up to two years depending on soil texture
Slow-Gro	Maleic-hydrazide	None
Treflan	Trifluralin	Season long control for the growing season

Do the following to reduce Phytotoxicity:

- Check the label for precautionary statements such as 'Harmful to sensitive plants'.
- Follow label directions when mixing and applying pesticides.
- Never combine or tank mix pesticides or adjuvants unless compatibility is known or stated on the label.
- Consider the residual activity of herbicides when establishing new turf or landscape areas. Some plants may not be able to grow in herbicide treated soil for months or years after treatment.

Summary

The use of pesticides in urban settings presents a number of challenges to landscape pesticide applicators. Guidelines must be followed to protect bystanders and other non-target organisms. Care must be taken to avoid drift and phytotoxicity, and to prevent unwanted release of pesticides into the environment. Following label directions, legislated requirements and the guidelines in this chapter help prevent contamination of nearby property and bodies of water.

Self–test Questions

Answers are located in Appendix A of this manual.

1. List two (2) things to avoid when using pesticides to protect the environment, public, sensitive vegetation, and pets from pesticide exposure.

   ____

   ____

2. Which of the following guidelines is false and would not protect the environment, public and pets?

   a. Use wick applicators, low pressures settings and coarse spray nozzles for sprayers. Use basal bark treatments to reduce drift.

   b. Increase spray pressure.

   c. Reduce the distance between the nozzles and the target.

   d. Apply under proper weather conditions. Look for low wind speeds, high humidity, and low temperatures.

3. What would you do to prevent bystander exposure to pesticides?

   ____

   ____

   ____

   ____

4. Residual activity is the length of time that a pesticide remains in the environment. **True or False?**

5. Which of the following operating guidelines prevent pesticides from being accidentally released? Select all that apply.

    a. Keep spray equipment (power hoses, backpacks, etc.) locked in vehicles, or service truck compartments when not in use and during transport.

    b. Be prepared to handle pesticide spills and other emergencies. Have a pesticide spill kit and emergency phone numbers on hand.

    c. Check hose connections every other year.

    d. Dispose of pesticides, empty containers, or excess spray mix on the client's property. Leave them behind for the client to handle.

Chapter

5

INTEGRATED PEST MANAGEMENT

Integrated Pest Management (IPM) is a prevention based way to manage pests effectively, economically, and safely. This approach helps reduce the need for chemical pesticides and can cut costs. IPM programs help to protect the environment, human health, and beneficial organisms. An IPM approach in landscape provides long-term answers to pest problems. As a result, pests can be managed, even when pesticides cannot be used.

IPM is a decision-making process. It is based on preventing pest problems. All information and treatment methods are taken into account. Pests are managed effectively, economically, and in an environmentally sound manner. The six elements of an IPM program are:

1. **Prevention:** Organisms are kept from becoming pest problems by planning and properly managing landscape and turf areas.

2. **Identification:** Pests and beneficial species are identified.

3. **Monitoring:** Pests, beneficial species, pest damage, and environmental conditions are monitored regularly.

4. **Injury and Action Decision:** Injury and action thresholds are used to decide when to treat pest problems.

5. **Treatments:** One or more treatment methods are used to control the pest. These include cultural, biological, physical, mechanical, behavioural, or chemical methods. Treatments are chosen that will have the least environmental impact while providing adequate control.

6. **Evaluation:** The effectiveness of the IPM program is regularly evaluated.

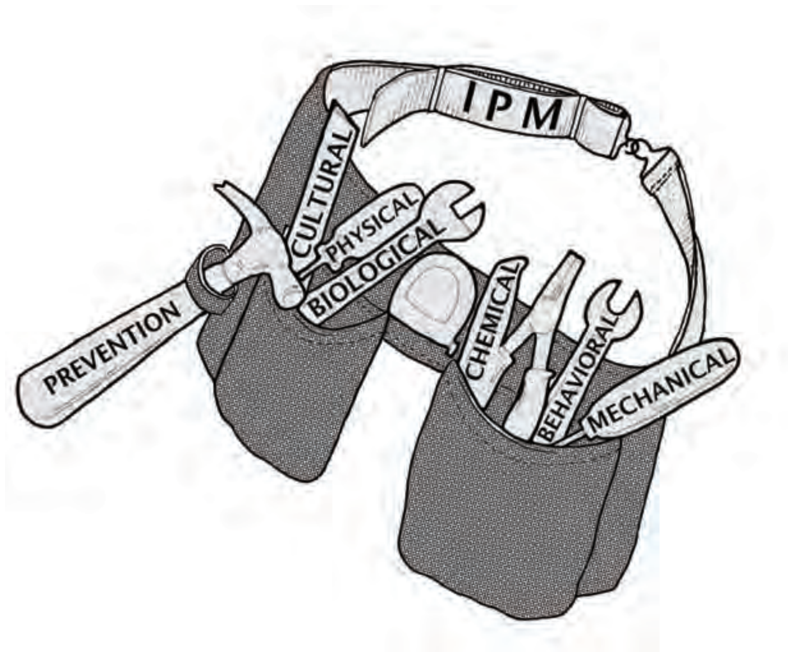


Figure 5-1: IPM programs use a tool box approach in which a variety of treatments are used to control pest problems.

For more general information on IPM, see Applicator Core Manual Chapter 7: Integrated Pest Management.

Urban lawns and landscape plantings are grown for their pleasing appearance. Other managed turf areas are maintained for a variety of reasons including professional and amateur sports, public recreation and urban green space. Despite this variety of use, the basis of all turf and landscape IPM programs is healthy plants. Keeping plants healthy in an urban environment poses a number of unique challenges. These include people pressures (such as traffic and wear), air pollution, compacted soils, and dry soil.

Most landscapes include a variety of trees, shrubs and other plants. In many cases landscape pest problems can be prevented in the design stage. Landscapers can choose from a number of plants that resist disease, are rarely attacked by pests, or are tolerant of urban growing conditions. In older landscapes, problem plants can be replaced with other species. A mixture of plants in landscapes keeps pest problems from spreading.

People who manage pests in landscape and turf areas must meet the standards required by their clients. These standards can be based on the appearance, use of the site or in some cases safety requirements. Standards vary from site to site. Some areas require very high standards (e.g., high value sports turf) while others are less stringent (e.g., roadway medians, playgrounds) These factors are used in setting injury thresholds. The needs of clients and site users can also affect the choice of treatments. Residential clients may not want certain types of pesticides to be used in their yards. Some types of treatment may not be practical or feasible on large turf areas. Municipal bylaws or policies may restrict pesticide use or prohibit the use of certain types of pesticides.

The strength of an IPM approach is that it can be applied to any type of site or pest problem. This chapter provides IPM principles that work for many kinds of pest problems. Examples of IPM programs for common pests in the Atlantic region are given. However, this manual does not cover all pest problems that can occur. References given at the end of the chapter will assist readers in finding more information.

Learning Objectives

Completing this chapter will help you to:

- **Know the unique IPM challenges in urban landscapes.**
- **Know the steps used to create an IPM program for a turf or urban landscape setting.**
- **Know how to group landscape sites by the level of care needed.**

Putting IPM into Practice

An IPM program should start small and be built up as experience is gained. An approach to planning an IPM program may include the following:

- Start with a small site.
- Select a site that has few pests.
- Focus on one pest (e.g., aphids) in street trees or a group of pests (e.g., broadleaf weeds in turf).

As knowledge is gained, broaden the program can be broadened to other areas.

Set Realistic Objectives

A pest management service should begin using IPM by working with a few interested clients. Golf course, sports and municipal facility turf and landscape managers should select a small area of their sites or a single pest problem to focus on.

Categorize Sites

Divide the area to be managed into groups or sites based on the level of care required and the level of damage that can be tolerated (see Figure 5-2). This helps you to know where to focus monitoring and treatment effort. It also allows different injury thresholds to be set for each group or site.

Any type of grouping system that works can be used. Below is an example of a how sites can be grouped into a three-level system. Many turf and landscape managers across Canada use this approach:

Class A Sites: Class A sites have high value and are highly visible. These are maintained to the highest standard. Often very little pest damage can be tolerated. These can include:

- Formal display beds
- Lawns in parks and around public buildings
- Front yards

- Botanical gardens
- Hanging baskets
- Golf course greens and tees
- Professional sports fields

Class B Sites: Class B sites have a moderate level of maintenance, value or visibility. A greater level of pest damage may be tolerated. These can include:

- Roadway medians
- Park and playground areas
- Backyards
- Perennial borders in parks
- Golf course fairways

Class C Sites: Class C sites are natural, low profile or low visibility sites that require little care. These can include:

- Nature parks
- Playground areas
- Works sites
- Golf course rough areas
- Parking lot beds

A golf course or large park can be grouped into a number of smaller areas. For example, the greens and tees on a golf course might be grouped as Class A sites. The fairways may be Class B sites. The roughs may be Class C sites. Each class of site would have its own injury threshold for each pest. In a large park, ornamental display beds may be Class A. Turf and shrub beds may be Class B. Picnic areas may be Class C.

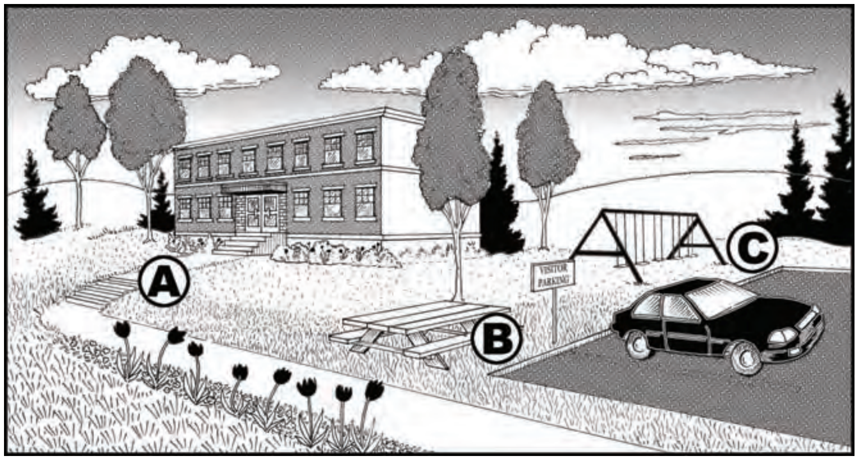


Figure 5-2: Divide the area to be managed into groups or sites based on the level of care required and the level of damage that can be tolerated.

Assemble Background Information

Before starting an IPM program, background information on the site must be collected and analyzed. This includes:

- Records of past pest problems or treatments at the site
- Provincial or municipal laws that apply
- Resources (e.g. local publications and pest management experts) that can be used in the IPM program
- Turf and/or landscape problems that are common in your area
- A listing of all treatments that can be used

An initial site assessment can provide background information. Inspect and record:

- Features of the landscape (e.g., drainage, soil quality, amount of shade)
- Plants on site (trees, shrubs, lawns, herbaceous plants, etc.)
- Use patterns (Who uses the site? When? What areas are most used? Are any areas damaged by over-use?)
- Environmental concerns or sites nearby that can affect the choice of treatments (e.g. sensitive plants, bird/animal breeding areas, water courses)

Analyze Assembled Information

To make sense of information:

- **Look for key plants or areas** in the landscape such as specimen trees, display borders, problem or high use turf areas. These can serve as a focus for pest management efforts.

- **Check past pest records** or question clients on problem plants or areas. Plants may need to be moved or replaced. Turf areas may need to be renovated or over-seeded. This can be done at once, or part of a long-term plan.

- **Look for ways to make changes** and improve long-term results. For example, people crossing a turf area may cause wear and bare patches. One solution is to install a path, or keep traffic from crossing the area by planting thorny shrubs or placing other barriers.

Draft an IPM Program

Use background information and analysis to draft an IPM plan. Address prevention, identification, monitoring, injury and action levels, treatments, and evaluation. For some elements, a great deal of information may be available. For others, there may be gaps that require research. Check reference books, talk to local experts, and gain experience.

Below are tips for creating a generic landscape or turf IPM program:

- **Prevention:** Prevention is often more effective than using a control treatment. Improved fertilizing, liming, and mowing helps turf resist weeds and chinch bug damage. A program of pruning, removal of plant debris and mulching can help landscape beds resist pest problems.

- **Identification:** All pests must be identified before action is taken. Become familiar with the common pests in your area and their look-alikes. Keep an identification collection or reference photos to help you diagnose problems. Use insect specimens (pinned or in alcohol), pressed weeds, and pictures of plant damage and disease.

- **Monitoring:** Choose simple monitoring methods. Have a standardized record keeping system that is easy to use. Set up a simple file system.

Information on each site should be on file so it is easy to find and use. Store maps, records, injury thresholds, treatment information, and other material for easy access.

- **Action Decisions:** Set temporary thresholds if there are no established injury and action thresholds. These can be based on past experience, or references. Thresholds can be refined with experience and monitoring data.

- **Treatments:** Put guidelines in place for when and how potential treatments will be made. Make sure all involved are well informed. If new products or tools are required, make sure they are ordered in advance. Check with suppliers to make sure items will be available when needed.

- **Evaluation:** Set a schedule to evaluate treatment effectiveness. At the end of the season, review the whole IPM program. All participants (e.g., clients, staff and crews) should be involved.

IPM Program Revisions

An IPM program evaluation is a rich source of information. It can be used to plan for the next season. Look at the IPM plan yearly to make improvements based on the results of evaluations, and to keep up on new products and tools that support IPM.

Summary

IPM programs take all information and treatment methods into account. These are used to manage pests in a cost effective and environmentally sound manner. An IPM approach in landscapes improves long-term pest management and can cut down on pesticide use.

To develop an IPM program:

- **Become familiar with the pests common to your area. Make sure that the landscape manager and key staff can identify the common problems they may encounter.**
- **Collect background information about the site, pest problems, and treatments that can be used.**
- **Set realistic goals.**
- **Start small and expand to other areas or pest types with experience. Group areas or sites by the level of required care.**
- **Draft a plan that includes all parts of IPM: prevention, identification, monitoring, injury and action thresholds, treatments and evaluation.**
- **Target effort and resources to where they are most needed.**
- **Review the IPM plan yearly and improve it with the experience that is gained.**

Self-test Questions

Answers are located in Appendix A of this manual.

Self test questions for chapters 5, 6, 7, and 8 can be found at the end of chapter 8 of this manual.

Chapter

6

INSECTS AND MITES

Insects and mites are common landscape pests. To manage them using IPM, you must:

- Identify them correctly
- Know their life cycles
- Know their biology
- Know the available treatments and their timing

The following section provides information on insect and mite biology. A range of available treatments is also discussed.

There are many species of insects. Many are beneficial and pollinate flowers, or prey on pests. A few species damage plants and become pests. Insects and mites are considered pests when they reach high enough numbers to cause damage (injury thresholds). When this occurs, they are usually controlled and steps are taken to prevent damage in the future.

However, it is often good to have pest species present in low (non-damaging) numbers. They can provide food for their natural enemies and other beneficial organisms. When pests are removed completely, their natural enemies starve or leave the area.

Adult insects have jointed bodies, jointed legs and an outer skeleton (exoskeleton). They have three main body sections: head, thorax, and abdomen. They have three pairs of legs. Most have two pairs of wings attached to the thorax. Insects breathe through spiracles (openings) in the outer skeleton. Most insects have compound eyes although some have simple eyes.

Mites are related to spiders. They have jointed bodies, jointed legs, and an outer skeleton. Mites differ from insects in that they have only two main body parts: a combined head and thorax section, and an abdomen. Adults have four pairs of legs although some only have three pairs of legs until they mature. All species of mites are wingless.

Insects and mites can damage plants through feeding or egg laying activities. Some insects such as flower thrips can damage plants when they lay their eggs inside the plant tissue.

Insects have a number of mouthpart types. Insects that damage landscape plants often do so by:

- Chewing (e.g. leaf beetles and caterpillars)
- Sucking (e.g. aphids)

Other insect mouthpart types include:

- Siphoning (e.g. butterflies and moths)
- Lapping (e.g. bees)

Mites feed by sucking plant sap. This causes damage that appears as browning or mottling of the leaves. Some species secrete a substance when feeding which causes galls to form on the plant (e.g., maple gall).

Learning Objectives

Completing this chapter will help you to:

- **Describe the body parts of insects and mites**
- **List major differences between insects and mites**
- **Give the two main types of insect life cycles**
- **Know common insect and mite pests. Know how to manage them using IPM**
- **Know the types of insecticides. Give an example of each**
- **Know what affects the effectiveness of insecticides**
- **Be familiar with the identification, biology and monitoring of common insects pests found in Atlantic Canada**

Life Cycles of Insects and Mites

Insects and mites change as they grow. They pass through three or four stages from egg to adult. Common stages are: egg, larva (or nymph for certain insects), pupa, and adult. A generation is the time that it takes for an insect to complete all of the life stages. Some species of insects and mites have one generation per year. Others can have two or more generations per year. For multi-generation species, the number of generations in a growing season will depend on climate and weather.

Insect Lifecycles

Metamorphosis is the change in insect shape and form as it develops from egg to adult. There are two main types of metamorphosis: complete metamorphosis and gradual (incomplete) metamorphosis.

Complete Metamorphosis

Insects that have complete metamorphosis (see Figure 6-1) begin as an egg. The **egg** hatches into a worm-like **larva** (e.g., caterpillar, maggot or grub). The larva is usually quite different from the adult in appearance. Larvae also eat food that is different from what is eaten by adults. Most larvae eat a large amount as they develop. As it grows, the larva sheds its skin (moults).

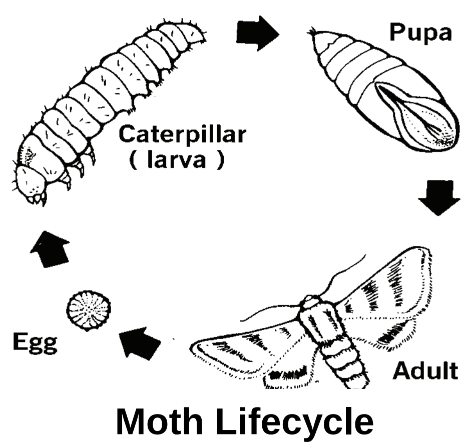


Figure 6-1: The moth lifecycle is an example of complete metamorphosis.

Some species can moult or shed its exoskeleton, three or more times during growth. Each stage between moults is called an instar. When a larva reaches full size, it transforms into a **pupa**. A pupa is a non-feeding stage that moves very little. Inside the pupal case, the larva becomes an **adult**. When the change is complete, the adult splits the pupal case open and comes out. The adult is the reproductive stage. In most species, adults have two pairs of wings. Some insects have no wings as adults. Flies have only one pair of wings.

Gradual or Incomplete Metamorphosis:

Insects that have gradual or incomplete metamorphosis (see Figure 6-2) start as an **egg**. The egg hatches into a **nymph** . The nymph looks like a small adult, but it has no wings or reproductive organs. The nymphs often live in the same habitat and eat the same food as adults. As the nymph grows, it moults. With each change, it looks more like an adult. On the last moult, the nymph develops into an **adult** with wings and reproductive organs.

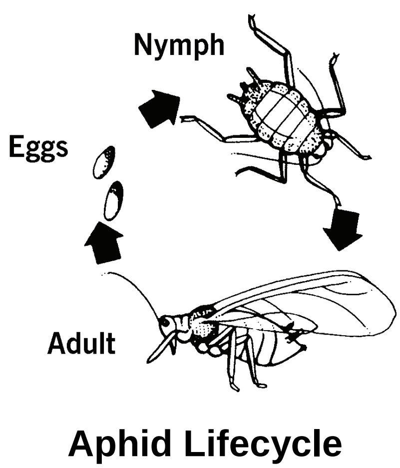


Figure 6-2: The aphid lifecycle is an example of gradual or incomplete metamorphosis.

Mite Life Cycles

Mites develop in four stages: egg, larva, nymph and adult. The adult is the reproductive stage.

Managing Insects and Mites

To manage insects and mites using IPM, ensure the pest is correctly identified and consider:

- The biology of the pest
- Its natural enemies
- The host plant
- The environmental conditions favoring development
- The available treatments (biological, physical, chemical)
- The risk of the treatment chosen to humans and animals
- How the pest can be prevented in the future

For additional information see **Chapter 2: Human Health; also Applicator Core Manual Chapter 7: Integrated Pest Management.**

A general IPM approach for insects in turf and landscape is described below. See the fact sheets at the end of this chapter for information on prevention, identification, monitoring, injury and action thresholds, treatments, and evaluation that apply to common pests in Atlantic Canada.

Prevention

In turf and landscape settings a variety of cultural practices are often used to prevent pest damage from occurring. Either the landscape or turf manager or the client can perform many of these tasks. If they are to be done by clients, the clients need to know the value of these practices and how they fit into the IPM program.

To prevent pest problems in ornamental and turf plants:

- On new sites, start with a good site design and planting plan.
- Make changes in existing sites to improve design.
- Make sure soil conditions are right for the intended plants.
- Evaluate and correct drainage, fertility, pH, soil texture and depth.
- Choose landscape plants (e.g., turf grass species) that suit the site and intended use. Choose resistant varieties where possible.

- Look at sun and shade, soil type, drainage, wind patterns, exposure, climate, and microclimates.
- Choose diverse species of families of trees and shrubs. This avoids monocultures that promote pest problems.

The 20-10 Planting Rule

To ensure diversity in the landscape, choose no more than 20% of plants from any one plant family. Have no more than 10% from any one genus. For example, 20% of shrubs and trees can come from the family Rosacea. No more than 1 in 10 plants should come from each genus (e.g., Pyracantha, Spiraea, Rubus, or Malus). For general use turf areas plant a mixture of turf grass species.

Select and Maintain Healthy Plants

Choose well grown planting stock that has been properly tended. Check the roots and foliage of new stock for pests before buying. Maintain healthy plants by doing the following:

- Give plants a good start through proper planting.
- Do not over-fertilize trees and shrubs.
- Use slow release nitrogen fertilizers on turf.
- Install irrigation that can be set to meet the water needs of landscape turf, shrubs, and trees.
- Prevent insects and diseases from damaging trees and shrubs. Use proper pruning methods to speed wound healing.
- Protect trees from injury by mowers, line trimmers, and construction.

Figure 6-3: Poorly maintained turf and landscape areas are more attractive to pests and are more likely to be damaged.

Insect Identification

The majority of insects found in landscape and turf areas are not pests. However, a number of insect species do attack the plants that are grown in Atlantic region landscapes. Of these only a few species do enough damage to warrant treatment.

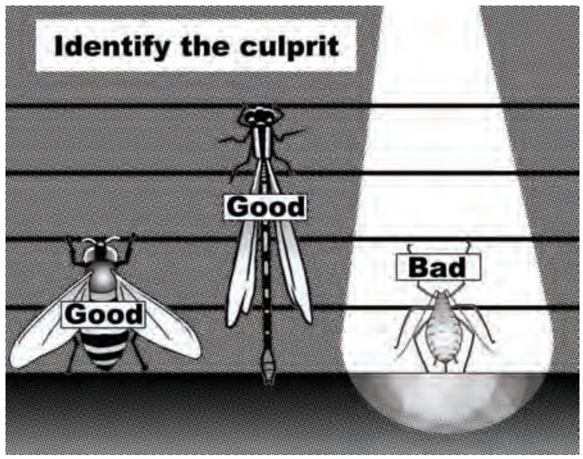


Figure 6-4: Many insects are found in the turf and on landscape plants but only a few species can actually cause damage.

It is as important to identify beneficial insects and mites as it is to identify pests. There are more beneficial species than pest species. An unknown insect is not likely to be a pest. Recognizing beneficial species allows you to decide if treatments are needed. Some species of beneficial insects help keep pest populations in check. A good-sized population of these can reduce the number of pests.

To identify insects and mites, use:

- Reference books and insect guides (given at the end of chapter 8)
- Local resources on the internet
- Agricultural colleges and universities
- Professional diagnostic services

Monitoring

Monitoring provides the information needed to make decisions on managing pests. It helps you to decide if treatments are needed. You can also decide where and when treatments are most likely to work. Monitoring programs can be based on the pest history of the site and weather conditions (e.g., growing degree days).

Monitoring for insects and mites is often done weekly when pests are expected. Keep written records of monitoring.

Insects can be monitored using the following:

- **Visual Inspections** use a hand lens or magnifying loupe to look at plant shoots, buds, leaves, bark and roots (if possible). Look for signs of insect damage such as curled, rolled or malformed leaves or shoots. Mite damage on leaves shows up as yellow and speckled areas and in some cases galls. Fine webbing may also be present. Look for sticky honeydew patches on leaves. Check for borer holes in tree trunks.

- **Indicator Plants** are landscape plants or turfgrass areas that indicate the presence of the pest. Careful observation over a number of years will reveal which plants in an area are most susceptible to attack by certain pests whether due to their age, variety or poor growing conditions. These plants can be used as an early warning system that a pest problem has emerged in the area. If these are checked first, and no pests are found, there is usually no need to check other plants. Using indicator plants requires careful observation and record keeping. The pest manager must know which plants to check first. This method is useful in checking for aphid attack in early spring.

- **Counting Methods** involve counting the number of insects found in a turf area, leaf samples or plant. This information can be compared to future counts. Some insects and mites can only be counted under a magnifying loupe or microscope. Insects in turf roots can be counted by removing a plug of turf or by folding back a measured section of sod. Count the insects in the soil among the roots.

- **Drenches (floatation method)** allow some turf insects (e.g., chinch bugs and leatherjackets) to be counted by driving them out of turf with an irritant drench of lemon-scented dish soap or mixed in water. Apply the drench with a watering can to a marked or measured area of turf, **OR** pour it into a large, bottomless tin can pushed 5 to 10 cm into the turf. After 15 minutes, larvae and adult sod insects will wiggle to the sod surface. These can be counted.

- **Pheromone Traps** are used to look for cutworms, leaf rollers, clearwing borers, and others. The trap has a pheromone lure that emits an odour that attracts the insects. Most traps use synthetic sex pheromones that simulate the odour given off by female insects to attract males. Each type of lure attracts only one species (or a few closely related species). The inside of the trap is coated with glue. Males are caught as they come to the trap. When using a pheromone trap, check it each week and count the number of males caught. The counts can be used to tell if the population of insects is reaching a peak. This allows you to time sprays, to have the most effect on young larvae shortly after hatching from eggs.

- **Sticky Traps** are yellow traps coated with glue. These are used in indoor plantscapes and greenhouses to catch whiteflies, flower thrips, fungus gnats, shore flies and other insects that are drawn by the bright yellow. Check the traps each week. Count the total number of insects and species caught. Bright blue traps can also be used for flower thrips. White traps can be used for tarnished plant bugs. Sticky traps also attract beneficial species. This makes them less suited for outdoor use.

- **Beating** involves sampling insects by shaking (shrubs) or beating the trunks of trees with a padded stick. The insects are knocked into a canvas tray held below. This method is used to count elm leaf beetles, leafhoppers, weevils, sawflies, and some species of caterpillars. It is also a good way to check for lady beetles, lacewings, and other beneficial insects. Mites on evergreens can be monitored by tapping foliage over a clipboard covered with a sheet of white paper.

Injury and Action Thresholds

It is difficult to set injury and action thresholds that work in all situations. Thresholds for insects and mites in the landscape can be defined using:

- Percentage of leaves damaged on a given plant
- Percentage of plants affected on a site
- Number of pests counted per leaf or shoot for landscape plants, or area for turf
- Number of pests counted against the number of beneficial insects present

For turf pests, the number of insects that can be tolerated (injury level) often depends on the health of the turf grass. Healthy turf quickly fills in thin or sparse areas caused by insect feeding. Poor turf can show damage from insect numbers that would have little or no effect on healthy turf.

Treatments

An IPM program often uses one or more treatment methods. Treatment can involve any combination of:

- Prevention or cultural methods (discussed above)
- Physical methods

- Mechanical methods
- Biological methods
- Chemical methods

Some treatments are more effective on immature stages (nymphs or larvae). Others are more effective against adults. Using a number of treatments that attack pests at different stages is more likely to succeed. For example, insecticides do not affect insect eggs and pupae. Many beneficial insects feed on insect eggs or pupae. Attracting beneficial insects and taking steps to protect them if insecticides are used can increase the success of an integrated pest management program.

Physical and Mechanical Control Methods

Physical control methods for pests on ornamentals include the following:

- Use strong sprays of water to control aphids, spider mites, and some sawflies, such as roseslug and pearslug (*Endelomyi* spp.).

- Remove infested leaves or branches by hand (e.g., pruning out webworm nests or removing scale infested branches).

- Use sticky tree bands to trap female winter moths when they climb trees to lay eggs in late fall. This should not be used during the growing season. It traps many beneficial species.

Biological Control

Promoting populations of native beneficial species is the most common way to use biological control in the landscape. Native species are free of charge; they just need to be protected. The best way to protect native beneficial insects and mites is to avoid using pesticides. If pesticides are to be used, avoid broad-spectrum pesticides and pesticides with a long residual activity.

Native beneficial insects are attracted to landscape plants for pollen and nectar. In many beneficial species, only the larvae are predators. The adults eat plant nectar. When females can feed on pollen and nectar, they are likely to stay in the area and lay eggs. These hatch into predatory or parasitic larvae that feed on pests. Many annual and perennial plants are good for attracting beneficial insects. Where possible, design a landscape planting to attract beneficial insects. This can be as simple as planting an edging of sweet alyssum around a bed of roses. This will attract predators of rose aphids.

Plants that Attract Beneficial Insects

Many ornamentals plants attract beneficial insects. These include plants in the:

- Carrot family (Apiaceae)
- Mustard family (Brassicaceae)
- Mint family (Lamiaceae)
- Aster family (Asteraceae)

Table 6-1: Plants that attract beneficial insects.

Plants that Attract Beneficial Insects	
Alyssum	**Phacelia**
Aster	**Potentilla**
Basket-of-gold (Aurinia saxatilis)	**Rudbeckia**
Beebalm (Monarda sp.)	**Salvia**
Calendula	**Schizanthus**
Candytuft (Iberis sp.)	**Shasta daisy**
Coreopsis	**Speedwell (Veronica sp.)**
Cosmos	**Sedum**
Feverfew (Chrysanthemum parthenium)	**Sweet alyssum (Lobular maritime)**
Golden marguerite (Anthemis tinctoria)	**Marigolds**
Thymes	**Verbena**
Goldenrod	**Yarrows (Achillea sp.)**
Lavenders	

Using Commercial Natural Enemies

Most beneficial species sold in Canada are intended for use in indoor plants and greenhouse vegetable crops. A few are useful in outdoor landscapes. There are restrictions on importing living organisms from the United States. Permits must be obtained from the Pest Management Regulatory Agency. A provincial permit may also be required. **Contact your provincial regulator to determine what additional permits are required prior to importing any species.** Examples of commercially available natural enemies include:

- **Aphid midge**, *Aphidoletes aphidimyza*: This is a native species. It is mass-produced to control indoor and outdoor aphids. These are used in roses, shrubs, and street trees outdoors. They are also used in nurseries and indoor plantscapes.

- **Insect parasitic nematodes** (several species are available): These are tiny parasitic worms that attack insects. They are mixed with water and applied as a soil drench. Parasitic nematodes control root weevil larvae, white grubs, and other soil insects. Each species of nematode is only effective against a certain species of insect.

- **Predatory mites**: A number of hardy native species *(Amblyseius spp.* and others) can be purchased. These control spider mites, European red mites, flower thrips, and cyclamen mites outdoors.

Most beneficial insect species for sale only attack a certain species of pest. Proper identification of pests is needed to avoid a wasted effort. Do some research before purchasing biological controls. Make sure that available species are the correct ones to control the pest problem. Talk to colleagues and experts with experience in biological controls. Contact vendors to find out availability and recommended release rates. Because biological controls are living, organisms and may perish, they must be handled carefully; most must be released as soon as they are received.

Types of Insecticides and Miticides

Insecticides are pesticides with active ingredients that are used to kill, attract, repel, or alter the growth of insects. Active ingredients can be natural or synthetic. Miticides attack mites. Insecticides and miticides are often classified by the way they work, their residual effect, and selectivity. The following are classes of insecticides and miticides:

- **Contact Insecticides and Miticides** must contact the pest to work. They can be applied to pests or to surfaces that pests are likely to touch. Some contact insecticides (e.g., malathion and methoxychlor) have a **residual effect**. These can kill insects (including beneficial species) for a number of weeks after application. Others (e.g., pyrethrins) break down within a few days.

- **Stomach Poisons** must be swallowed by the pest to be effective. They are often applied to the plant where the pest is feeding.

- **Systemic Insecticides and Miticides** are a special group of stomach poisons. They are often applied to the host plant and move inside the plant tissue through sap. Target pests are killed when they suck poisoned sap or eat poisoned plant parts. Dimethoate is the only systemic insecticide used in landscapes. It is both a systemic and contact pesticide.

- **Suffocating Insecticides and Miticides** are mainly horticultural oils. They clog the breathing systems of insects and mites. They can also disrupt egg membranes and keep them from hatching. Dormant oils are used for scale and other insect pests when trees are dormant during winter. Summer, or growing season oils can be used on some landscape plants while they are in leaf.

- **Fumigants** work as gases. In soil fumigation, they are applied to soil and move through air spaces between soil particles. Insects and mites breathe poisonous fumes and are killed. Fumigants are not used in landscapes. Landscape use is limited to treating infested soils in nursery production of ornamentals. **A separate class of pesticide applicator certificate is required to apply fumigants.**

- **Insect Growth Regulators (IGRs)** are natural or synthetic insect hormones. IGRs disrupt normal moulting and growth. These hormones disrupt development at crucial times in the life cycle. The pest dies before reaching the adult stage and does not reproduce. Kinoprene is an IGR for use on certain greenhouse ornamentals to control aphids and whiteflies. Tebufenozide is another IGR used to control the caterpillar stage of moths (e.g., codling moth, leafrollers, winter moth, and others).

- **Silica Dusts or Gels** kill crawling pests by causing them to dry up. Contact insecticides are sometimes mixed with these powders. Silica pesticides are not often recommended for use in landscapes. As they also kill beneficial insects. Silicon dioxide (diatomaceous earth) is the active ingredient in a number of silica dust pesticides used for crawling insect pests. They are often used in buildings for structural pest control.

- **Sticky Glues and Pastes** are spread on surfaces or traps to capture insects. Colours (bright yellow, white, or bright blue) or chemical attractants are used to draw the insects to the traps. Sticky pastes are used as barriers to capture crawling pests. Sticky bands on tree trunks are used to capture female winter moths. They cannot fly and must climb tree trunks in late fall to lay eggs. Tree bands can be used to catch ants that protect aphid colonies on trees and shrubs. However, in general, they are not often advised for outdoor trees during the growing season because they also capture many beneficial insects.

- **Microbial Insecticides** contain microorganisms (tiny organisms). Most are insect diseases. Microbials are often sprayed on plants that are being eaten by larval insects. Once the microbes are eaten by the insect, they cause it to become ill. *Bacillus thuringiensis (BT)* is the most widely used microbial insecticide. The bacteria produce a toxin in the insect's stomach that prevents food from being absorbed into its body. The insect stops feeding immediately. After several days, it dies from starvation. Microbials are selective. The disease effect is often limited to a few species of related insects. For example, *BT* strains that affect caterpillars (*Bacillus thuringiensis kurstaki*) do not harm birds or beneficial insects that feed on caterpillars. *Bacillus thuringiensis israelensis* is used for certain fly larvae. It is mainly used on ornamentals for fungus gnat larvae control in greenhouse production. *Bacillus thuringiensis tenebrionis* affects certain beetle larvae (e.g., elm leaf beetle).

When choosing insecticides to use in IPM, the following should be considered:

- **Residual effectiveness** is the length of time that an insecticide remains effective after being applied. Some insecticides do not have a residual effect (e.g., insecticidal soaps or horticultural oils). Others have a short residual period of a few hours (e.g., pyrethrins). Some insecticides have a residual period of a number of weeks. Pesticides with short, or no residual effects are best suited for use in an IPM program. They have the least impact on natural enemies of pests. When a monitoring program is used, applications of insecticides can be correctly timed. Long residual effects are not needed.

- **Selectivity** is the tendency of an insecticide to only control certain insects or mites. They do not harm a broad range of insects, mites, or non-target organisms. For example, the microbial pesticide *BTK* only affects certain caterpillars. **Non-selective** insecticides affect a wide range of insects or mites, including beneficial species. They can also harm non-target organisms. Extra caution should be taken to limit the use of these insecticides. Ensure that they are only used when and where monitoring shows they are needed.

Factors Affecting Insecticide and Miticide Efficacy

The effectiveness of insecticides and miticides is affected by a number of factors including:

- **Timing of application:** Some life stages of insects and mites are not affected by pesticides. For example, many pesticides have little effect on insect eggs or pupae. In most cases, the younger the larval stage, the easier it is to control with contact and stomach poisons. Some pesticides work best on the adult stage.

- **Weather conditions:** Temperature, humidity and rain can interfere with some pesticides. High temperatures can quickly break down some chemicals. Frost can impair the effect of sprays such as horticultural oils. Rain can wash sprays from plants before pests come into contact with them.

- **Resistance:** Some species (mainly farm crops) have developed resistance to some pesticides or pesticidefamilies. Refer to the **Applicator Core Manual** for more information on resistance.

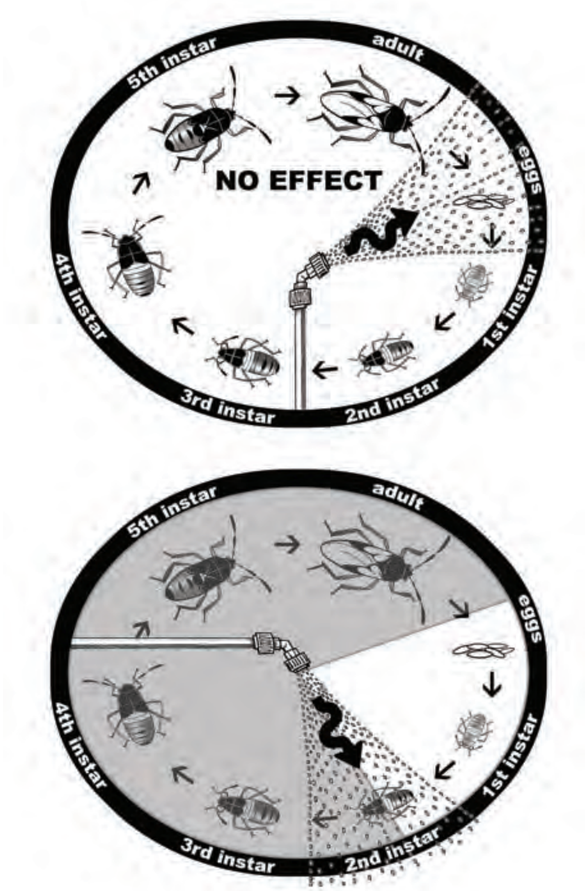


Figure 6-5: If pesticides are applied at the wrong stage of a pest's life cycle, they will not control the pest. Each pest has an optimum time/stage in their lifecycle where pesticide treatment is most effective.

Evaluation

At the end of each season review all aspects of the IPM program, consider the results obtained and identify any changes that can be made to improve the program's effectiveness. Before the next season starts, determine if there are new products and tools that could be used in the program.

Slugs and Snails (Molluscs)

Slugs and snails are molluscs. They have soft-bodies and move using a single "foot." They have a distinct head with two pairs of tentacles. Snails have shells, while slugs do not. Molluscs are common landscape pests in wet and humid areas of the region. To use IPM, you must first establish that slugs are causing a problem. They are often identified by their damage, because they are active at night. To plan proper control, it is important to know their biology. The following section provides information on mollusc biology and available treatments.

Life Cycle of Slugs and Snails

Snails and slugs have three stages in their life cycle. They begin life as round or oval translucent eggs. These eggs are often laid in jelly-like masses. The eggs hatch to produce immature nymphs. The nymphs mature into the adult stage. It may take a number of months to years for slugs to mature.

Managing Slugs and Snails

Land slugs and snails are mainly active at night, on cool cloudy days, or right after rain. During the day they hide in moist areas under objects or debris on the soil surface. Slugs and snails are somewhat territorial. They return to the same hiding place nightly. Molluscs leave slime trails as they travel. Slime protects molluscs from injury. Slime trails can be used to determine the cause of damage to plants. When conditions are dry, molluscs tend to avoid dusty, dry, and sharp materials. These materials can be used to protect plants when conditions are dry. They will not protect plants in wet conditions.

An IPM approach for dealing with molluscs is described next:

Prevention

Change the conditions that allow molluscs to thrive. Remove objects and refuse from the surface of the soil. These serve as hiding places for slugs and snails. Thick organic mulches and weeds provide slug habitat. They should be removed from perennial beds and borders in the spring when conditions are wet. Irrigate landscape beds in the morning. This will allow the soil surface to dry out before evening when slugs are active.

Identification and Monitoring

Signs of mollusc damage include ragged holes in leaves and slime trails. Molluscs can be seen feeding on plants at night using a flashlight. This helps you to see the extent and location of the problem.

Treatments

Physical Control

- **Copper strips** repel molluscs. Strips can be wrapped around trunks of woody plants or used as edging on nursery beds. Slug barrier tapes can be bought in stores.

- **Baited traps** attract and drown slugs in fermenting liquid. Baits include beer or yeast dissolved in water. Baits can be set out in homemade or purchased traps that are set in the soil. The trap lip is set flush with the soil surface.

- **Hand picking** can help control molluscs if done on a regular basis. During the day, slugs can be found under boards or other objects and destroyed. If performed daily, this can deplete the local slug population. Slugs are territorial. It takes time for slugs to move in from elsewhere.

Chemical Control (Molluscicides)

Molluscicides are pesticides that kill, attract, repel, or alter the growth of slugs and snails. Common molluscicides attract slugs to feed on bait pellets that contain pesticide. There are two active ingredient registered for use in Canada:

- **Metaldehyde**: Metaldehyde is the oldest and most widely used molluscicide. It attracts and poisons slugs. Liquid and bait formulations are available. In bait form, it can be quite attractive to dogs and can result in poisoning. It poses a risk to children, pets and wildlife if eaten.

- **Ferric (iron) phosphate**: Ferric phosphate is a newer molluscicide. It comes in bait pellets. Ferric phosphate is quickly replacing pesticides with metaldehyde. It is not as attractive or poisonous to non-target organisms. The bait is eaten by molluscs. It disrupts slime making. This causes the molluscs to dry up and die.

In Review

There are many species of insects and mites. Only a few species cause damage to plants. Insects and mites damage plants by feeding or by laying eggs in plant tissue. Insects have three main body sections: head, thorax, and abdomen. Most adult insects have three pairs of legs and two pairs of wings. Mites, which are closely related to spiders, have a combined head and thorax section and an abdomen. Adult mites have four pairs of legs and are wingless. Insects and mites change as they grow through a process called metamorphosis. To manage insects and mites using IPM, ensure the pest is correctly identified and consider:

- **The biology of the pest**
- **Its natural enemies**
- **The host plant**
- **The environmental conditions that favor development**
- **The available treatments (biological, physical, and chemical) The risk to humans and animals**

Treatment can involve any combination of:

- **Prevention or cultural methods**
- **Physical methods**
- **Mechanical methods**
- **Biological methods**
- **Chemical methods**

There are many different types of insecticides that can be used to control pest insects. When choosing insecticides to use in an IPM program, consider the residual activity and selectivity of the pesticide.

Common Landscape Insect Pests In Atlantic Canada

Knowing an insect's biology will help you find the best way to monitor its development and decide if control is needed. To plan effective IPM program applicators need to know the following:

- The insect's lifecycle
- When the insect can be found in your area
- What part of the plant it feeds on or damages
- Where it hides when it is not feeding

The pests listed in Appendix B are the ones that are most frequently encountered by landscape managers in Atlantic Canada.

The information in Appendix B has been provided in fact sheet form to assist pesticide applicators to communicate with their clients and users of the facilities that they manage. These fact sheets can be reproduced and distributed to your clients. This section includes information on the following pests:

- Aphids
- Sawflies
- Fall webworm
- Birch leafminer
- Lilac leafminer
- Elm leafminer
- Antler moth
- Hairy chinch bug
- White grubs
- Leatherjackets/European crane fly

Self-test Questions

Answers are located in Appendix A of this manual.

Self test questions for chapters 5, 6, 7, and 8 can be found at the end of chapter 8.

Chapter

7

WEEDS

Weeds are a common problem in turf and other landscapes areas. To use an IPM approach, you must be able to identify weeds, know their life cycles, and their biology. To choose proper treatments, it is important to know how they work. The following section provides information on weed biology and treatments. A sample IPM program for broadleaf weeds in turf is included.

A weed is any plant that is growing where it is not wanted. Some weeds (mainly introduced species) are considered noxious weeds under provincial law. They can cause harm by contaminating farm crops and grazing areas. Some weeds (e.g., ragweed) cause allergies in people.

Landscape weeds are problems when they:

- Compete for light, water or nutrients and slow the growth of desirable plants
- Detract from ornamental beds and lawns
- Reduce visibility around intersections, roadsides, and signposts
- Choke ditches and drainage swales, (a shallow troughlike depression that carries water mainly during rainstorms or snow melts).

Learning Objectives

Completing this chapter will help you to:

- Know common problem weeds.
- Know how to manage them using IPM.
- Know what affects the effectiveness of herbicides.

Life Cycles of Weeds

To develop an IPM program for weeds, you must know the weed species and its life cycle. Weeds can be classified by how long they live:

- **Annuals** complete their life cycle within a year. Most produce a large number of seeds to ensure survival. Summer annuals germinate in the spring. Winter annuals germinate in the fall.
- **Biennials** live more than one, but less than two years. They grow from seed that often germinates in the spring. During the first year, they store food (often in short fleshy roots). Foliage grows into a rosette of leaves. The plant uses the stored food in the next season. It quickly grows and sends up flower stalks. It produces seed in the summer or fall. It then dies.
- **Perennials** live more than two years. During the first year, the plants grow and store food reserves. Often, they do not produce seed the first year. In most cases, seed is produced in the second year and every year after that. Most perennial weeds spread using seeds. Many also spread using creeping stems or stolons, creeping roots, rhizomes, or bulbs. Perennials can be shallow or deep-rooted.

Identifying Weeds

To identify weeds you must look at a number of plant parts:

- **Leaf** shape and arrangement on the stem can be used to help identify species. Leaves may be compound (made up smaller leaflets) or simple. Edges of leaves may be smooth or toothed. The surface of the leaf may be smooth, hairy, or have prickles or spines. Leaves may be arranged on the stem in opposite pairs. Leaves may alternate on the stem or be found in whorls. For seedlings, the cotyledons (seed leaves) can be used in identification.
- **Stems** may be woody (e.g., shrubs) or herbaceous (soft, not woody). Plants may have upright or branching stems. The branching habit may be upright or spreading.

- **Flowers** may be arranged on a stem as single flowers or as a number of blossoms in spikes or flat heads. Other patterns of flower arrangement also exist. It is important to note the:
    - Number of petals and sepals
    - Shape and characteristics of reproductive parts, known as pistils and stamens
    - Shape and appearance of seeds
- **Roots** may be fibrous or tuberous. Weeds can have single taproots, highly branched fibrous roots or creeping jointed rhizomes.

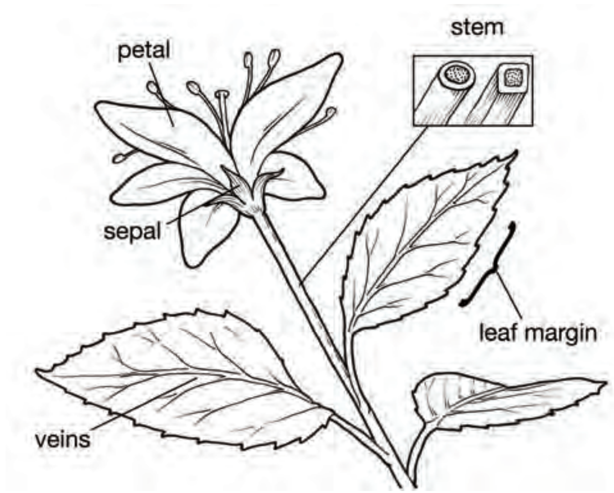


Figure 7-1: Weeds are identified by looking at a number of plant parts.

Leaf Stages

It is important to be able to identify desirable plants and weeds in the leaf stage. Many herbicides are only effective at certain stages of growth. If applied too early, there may not be enough leaf area for the herbicide to work. If applied too late, the weed may survive or set seed. Size and number of leaves can quickly increase. You must check weeds regularly when using a herbicide that only works at certain stages of the weed's growth.

Leaf Stages of Broadleaf Plants

The leaf stages of broadleaf plants are as follows:

- **Cotyledons** are the first leaves that emerge from a seed and are often different in shape from true leaves. They may quickly dry up and disappear. On a few plants, they stay beneath the soil. The timing of herbicide applications may be based on the average number of leaves on the plants. When counting leaf numbers to plan a herbicide application, do not include cotyledons.
- **True leaves** are the leaves that appear after cotyledons. These can be used to identify plant species.

Leaf Arrangement

Leaves are arranged along the stem in patterns. The following are common patterns:

- **Alternate leaves** emerge from alternate sides of the stem. They are not directly opposite each other.
- **Opposite leaves** grow in pairs from the same point on the stem. They appear across the stem from each other.
- **Whorls** of leaves emerge as three or more leaves sprouting from the same stem point on the stem.

When counting leaf numbers, count each true leaf (unless your identification guide refers to the number of whorls or leaf pairs)

Some plants (e.g., clover) have compound leaves. Compound leaves are made up of a number of leaflets. When identifying weeds, do not count the leaflets of a compound leaf as separate leaves. Each grouping of leaflets compound leaf is counted as one compounds leaf.

Leaf Stages of Grassy Plants

Leaf stages of grassy plants are as follows:

- **The coleoptile** is the first leaf. It is a single protective sheath. It stops growing when the tip breaks through the soil surface.
- **True leaves** are the next to emerge. These are used to identify plant species. They emerge alternately along the stem.

- **Tillers (or stolons)** are secondary shoots of a grass plant. They emerge from the base of the plant.

When counting leaves of grassy plants, count the leaves on the main shoot. Do not include the coleoptile or tillers in a leaf count.

Managing Weeds

The following section outlines a general IPM program for weeds. It includes prevention, identification, monitoring, injury and action thresholds, treatments, and evaluation. For more information on IPM, see the **Applicator Core Manual Chapter 7: Integrated Pest Management.** Manage landscape weeds by preventing them. Long-term control is often based on removing or changing conditions that allow weeds to grow. The effect on non-target plants should be taken into account when planning treatments. It is important to also consider the impact on desirable plants, the environment, and human safety.

Prevention

Prevention methods disrupt the life cycles of weeds. This makes growing conditions poor for weeds. Weed problems can be prevented with the following:

- Design hard surface areas. This eliminates areas where weeds can grow. Fill cracks and spaces where weeds germinate. Install paved or mulched strips under fence lines. These eliminate the need for herbicides.

- Do not bring weed seeds into sites. Control weeds in nearby areas that may spread seeds. Clean machinery and footwear before moving from a weedy area to a clean area. Use only well-composted manure or soil amendments that are free of weed seeds.

- Ensure plants are provided with the proper growing conditions**.** This allows them to compete with weeds. Water, fertilize, and manage plants to ensure that they are healthy.

- Use ground-cover plants or mulches that compete with weeds. These cover the soil surface and prevent germination of weed seeds. Use low ground covers or mulches under shrubs. Sow grass or wildflower mixtures in disturbed areas and along roadsides. Use nurse plants (e.g., clover or annual grasses) to cover the soil and shade out germinating weeds while turf grasses are being established.

Monitoring

Weeds in turf are usually checked once or twice a year using the methods on the following page. Weeds in other locations (e.g., hard surfaces, shrub beds, borders) can be monitored by doing the methods that follow. The monitoring schedule for weeds in hard surface and landscaped areas depends on site visibility, classification and maturity. Newly established landscape beds may require more frequent monitoring and treatment until the plants are established.

- Count the number of plants along a transect (see the following section: **Methods for Counting Weeds in Turf**).
- Note the portion of ground or pavement that is covered with weeds.
- Monitor the height or rate of growth of the weeds.
- Note the weeds stage of growth (e.g., newly germinated, forming flowers, seed heads, etc.).
- Note the species of weeds present, especially any noxious or invasive species.

Methods for Counting Weeds in Turf

There are a number of methods for counting weeds in turf. Examples include:

- **Transect Method:** To count weeds, use a rope or string to stake out a 10 meter transect (straight line) through an area of turf. Walk along the line. At each of 10 points, record the number of plants seen in a 10 cm^2 area. The line can be marked or knotted to show where to count. Counts can also be done by checking weeds at each large stride along the transect. Check 10 or more transects per site. Determine the average number of weeds per counting line

Transect Method Example:
Total # of plants found at 10 different points along transect

5+0+2+3+0+0+0+2+10+2 = 24 plants

Average # of weeds = Total # ÷ 10
= 24 ÷ 10 = 2.4 weeds/m^2

- **Grid (Quadrat) Method:** Make a one metre square wire or wood frame. Drop it randomly on turf. Count all weeds inside the frame. Count at least 10 squares per site. Average the scores to get an estimate of the number of weeds per square meter.

Grid (Quadrat) Method Example:
Total # of plants found in 10 different grids or quadrat

5+10+12+3+0+6+0+0+0+2 = 38 plants

Average # of weeds = Total # ÷ 10
= 38 ÷ 10 = 3.8 weeds/m^2

Visual Estimation:

- **Weed** cover can also be ranked high medium or low based on visual estimates of weed density. For example high > 50% weeds, medium 20-50 % weeds and low < 20% weeds

In an IPM program site specific threshold levels are established for the various areas being managed and weed counts are compared to threshold to determine if and when treatment is needed.

Injury and Action Thresholds

Injury thresholds for weeds can be based on:

- The number of weeds per square metre (e.g., turf) or number per length of row (e.g., in a display bed or along a fence line)
- Plant height (e.g., visibility in natural areas or roadsides)
- Plant species present (e.g. noxious, tall-growing or invasive species must be controlled.)
- Percent weed cover

The following are examples of common injury thresholds for broadleaf weeds in turf. These are given by category of site area as outlined on page 5 of this chapter:

- **Class A sites** are often meant to be "weed free". Site users perceive turf with up to 5-10% weed cover as weed-free. A common treatment threshold for herbicides on a Class A site is 10-15% weed cover.
- **Class B sites** are seen in many municipalities where 20% to 50% weed cover for turf is acceptable, as long as use of the site is not affected.
- **Class C sites** may exceed 50% weed cover. Thresholds can be based on height (e.g., for mowing) or when there is risk of fire or impairment of sight lines (e.g., on roadsides and corners).

Note: The threshold may be zero on all classes of sites for noxious weeds or weeds which present a safety or visibility hazard

Treatments

A number of treatment methods are described in the **Applicator Core Manual** and below. Use treatments singly or together. Treatments must be properly timed to be effective.

Physical and Mechanical Controls

There are a number of physical and mechanical controls for weeds. These include mulches, mechanical cultivators or mowers, and heat applicators.

- **Mulches** smother germinating weeds and shade the soil so that seeds cannot germinate. Mulches can be organic or synthetic. Organic mulches (e.g., leaves, straw, shredded bark, wood chips, etc) must be at least 10 cm deep to prevent weed growth. Synthetic mulches (e.g., geotextiles and weed mats) allow moisture and air into the soil. They block light from the soil.
- **Mowers and cultivating equipment** are commonly used to control weeds. This includes soil cultivators that destroy seedlings, and mowers that remove plant tops before seeds set. Brush saws, flails, and heavy mowers can also be used to cut back woody plants.
- **Heat Applicators:** Heat applicators kill weeds by damaging the plant tissue. A number of systems use heat to destroy plant foliage. The heat does not go into the soil and kill the roots of established weeds. A number of applications may be needed to deplete the energy stored in the roots of established plants. Heat application works best when the heat is applied for a very short time to stress plants. This works better than heating plants until damage can be seen. Heat application equipment includes the following:
  - **Flamers** range from small hand-held propane devices to tractor-mounted flamers.
  - **Hot water or low-pressure steam applicators** are often mounted on small trucks or trailers. Smaller hand-held versions are coming into the market.
  - **Infrared radiation applicators** burn propane and radiate heat. They range from hand-held applicators (used for dandelion spot treatments in turf) to tractor-mounted units.

Biological Control

Insects and disease organisms can be used to control weeds. Many insect species have been released in Canada to control introduced (non-native) weeds. These are often released by provincial and federal agencies over a large area or region. Most are used to control weeds that harm grazing livestock or take over grazing lands. An example is the cinnabar moth that was released in the Atlantic Provinces to control tansy ragwort. **Contact your provincial regulator to determine what additional permits are required prior to importing any species.**

Some plant disease organisms are being investigated to control weeds in Canada. Research is ongoing to commercialize a fungus that controls dandelions.

Use of Herbicides

Herbicides are pesticides that are used to kill, prevent, or alter the growth of plants. They can be natural or synthetic. Herbicides are classed by selectivity, mode of entry, timing of application, and residual effectiveness.

Selectivity

Selective herbicides only kill or damage certain plants. Examples include 2,4-D, dicamba, and mecoprop. These affect broadleaf weeds but not grasses. Non-selective herbicides (e.g., glyphosate) kill or damage all plants in a treated area. Some herbicides can be selective or non-selective depending on the application rate that is used.

Mode of Entry (how the herbicide enters the plant)

- **Contact herbicides** (e.g., fatty acids or acetic acid) kill plant parts that contact the herbicide. There is little or no movement of herbicide in the plant. Contact herbicides work against annual weeds, but only "burn off" the tops of perennials.
- **Systemic Herbicides** include glyphosate, amitrole, bromacil, and simazine. These herbicides enter the roots or aboveground plant parts and move (are translocated) within the plant. Effects may not show for a week or more after treatment. If the herbicide is too concentrated, it may kill cells too quickly when it contacts the leaf or stem tissue. This prevents movement of herbicide to the site of action in a plant. This will reduce effectiveness.

Timing of Application

Not all herbicides should be applied at the same time. Read the pesticide label for instructions on a given herbicide.

- **Pre-plant herbicides** (e.g., dicamba) are applied to soil before the desired plants are seeded or transplanted. These herbicides are often incorporated into the soil.

- **Pre-emergence herbicides** include borate, dichlobenil, or simazine. These herbicides are applied to soil after planting, but before either the desired plants or target weeds emerge. They control weeds before or soon after they emerge.
- **Post-emergence herbicides** (e.g., glyphosate or amitrole) are applied after the desired plants or target weeds have emerged. They control established weeds. Application may be soon after emergence, or up to a given height or leaf number.

Residual Effectiveness

- **Non-residual herbicides** quickly lose their effect in the soil after application. They do not affect future plantings. Examples include acetic acid herbicides, fatty acid herbicides, and products containing glyphosate.
- **Residual herbicides** (e.g., dicamba and simazine) break down slowly. They can control weeds for a number of weeks or even years. Caution should be taken when choosing to use a residual herbicide as nearby desirable plants can be affected by the herbicide through leaching, erosion, or runoff .
- **Soil sterilants** are a special group of residual herbicides. Examples include amitrole or bromacil. These are non-selective, residual herbicides. They are applied to soil to prevent plant growth for a long time (months to years). They do not sterilize the soil of all microorganisms or seeds. Soil sterilants are sometimes used on parking lots or roadways in landscaped areas. The use of soil sterilants is not covered under the Landscape Pesticide Applicators Certification. **Contact your provincial regulator to determine what additional certifications and/or permits are required prior to use of soil sterilants.**

Residual Herbicides – Additional Comments

Care is required when using residual herbicides. Residual herbicides can damage trees and shrubs with roots that extend into the treatment area. A buffer zone between the application site and nearby woody vegetation should be given on the label. If it is not given, the buffer width should be no less than two times the height of the desired woody vegetation. For further information on buffer zones see the **Applicator Core Manual.**

Do not apply residual herbicides in areas with a high water table or coarse-textured soil. These can lead to groundwater contamination.

Residual herbicide use can limit the future use of treated areas. A residual herbicide should only be used if present use will continue for a longer time than the residual period of the herbicide. The persistence of residual herbicides may vary. (See **Chapter 4: Table 4-1** of this manual) Persistence depends on the product, rate, formulation, concentration, weather, and soil conditions. Avoid using residual herbicides on steep slopes or areas subject to erosion and runoff. Movement of herbicide-contaminated soil can cause off-site damage.

Factors Affecting Herbicide Efficacy

- **Leaf Characteristics:** The shape and surface of leaves can affect the effectiveness of herbicides. Thin upright leaves are hard to cover with spray. Hairy or waxy leaf surfaces can repel herbicides or reduce herbicide contact. Additives (surfactants) can be put in the spray mix. These allow herbicides to adhere to and penetrate the leaves. **Additives can only be used if recommended on the herbicide label.**
- **Weather:** Temperature, humidity, rain, and wind can all affect herbicide performance. Moderate weather conditions are better than extremes. Check the herbicide labels to find out which weather conditions to avoid. Cool or dry conditions slow the production and movement of food in plants. This impedes the movement of systemic herbicides. Hot, dry weather can cause a herbicide to quickly evaporate from leaves. This reduces effectiveness. With high temperatures, plant cells harden. This makes it difficult for herbicides to enter plants. Rain during or after an application can wash foliar herbicides off plants. Some soil applied herbicides require irrigation or rain after application. Wind can cause drift and damage desirable plants. It can also prevent the herbicide from reaching the target.
- **Age of the Weeds:** Consider the following ways that the age of the weed will effect herbicide effectiveness:
    - Herbicides often work best on young, rapidly growing plants. Systemic herbicides (which move within plants) move faster through young, quick-growing tissues.

- Herbicides are less likely to kill weeds that are in full flower or producing seed. At this stage, sap movement within the plant is much slower.
- Broadleaf perennial weeds often become more resistant to herbicides as they age. They may become more susceptible again in the bud or early flowering stage. At this stage, the herbicide may move with carbohydrates to be stored in the roots.
- Herbicides for grassy perennial weeds work best in spring when plants have 4-5 leaves. They also work well in the fall when nutrients are being moved to underground parts of the plants.

- **Soil Types and Characteristics:** Higher application rates may be needed for soil-active herbicides on organic (peat or muck) or fine-textured soils (clay or silt). These soils hold (adsorb) more herbicide on the soil particles. This cuts down on the amount of herbicide available for weed control. Sandy soils often need less herbicide. Read the herbicide label to find minimum and maximum rates. There is an increased risk of lateral (sideways) movement of water and herbicide in clay and compacted soils.
- **Soil Moisture:** Soil-applied herbicides often work best in warm, moist soil. Soil moisture helps the herbicide move to the weeds. Systemic herbicides also work best on weeds that are growing in moist soils.
- **Cultivation:** When establishing new areas, cultivating before a herbicide application can increase or decrease its effectiveness. The effect of cultivation depends on the weed and the herbicide. Some weeds may be easier to control when they are weakened by cultivation. Other weeds may be broken into pieces and become harder to control with systemic herbicides. Read label directions before cultivating. This will identify whether it is helpful to do so. Cultivation may help weed seeds to germinate. The resulting weed seedlings will be easier to kill with later cultivation, or by using heat or herbicides.
- **Herbicide Resistance:** There are increased reports of agricultural weeds developing resistance to herbicides. These resistant weeds can also become a problem in landscapes. See **Applicator Core Manual** for resistance management information.

A Sample IPM Program for Broadleaf Weeds in Turf

The parts of an IPM program include:

- Prevention
- Identification
- Monitoring
- Injury and action thresholds
- Treatments
- Evaluation

Prevention

Weeds are the most common and most visible pest problem in lawn areas. They can also be a problem in sports and recreational turf. Weed problems usually begin in areas where the turf is in poor condition, the soil is compacted, or the turf has been heavily damaged by insects or disease. This causes thin or bare areas and allows the weed seeds already present in the soil to quickly germinate and grow. Healthy turfgrass plants can easily compete with weeds in the turf. Maintaining healthy turf is the best way to prevent broadleaf weed problems.

Before seeding or laying sod:

- Make sure soil is deep enough for healthy turfgrass (e.g., 15-20 cm deep).
- Add lime and soil amendments to correct pH and soil fertility.
- Correct soil compaction and drainage problems.
- Choose turfgrass cultivars and mixtures that are suited to conditions and planned use.

Deplete the weed "seed bank" in the soil. Allow weed seeds to germinate in bare soil. Cultivate to destroy the sprouting seedlings. Repeat the process. Make each cultivation shallower than the one before. This avoids dragging more seeds into the germination zone.

In existing lawns, weed seeds can germinate and fill in bare spots or where turf is thin from mowing too short. Dense turf, mowed to a height of 5 to 9 cm, shades the soil. This prevents weed seeds from germinating. It also prevents weed seedlings from getting enough space and light to survive. Different mowing heights may be needed, depending on the time of year. Summer mowing heights should be set high.

Turf management programs should be reviewed and corrected when broadleaf weed numbers increase. To help turf to compete with weeds:

- Use proper fertilization for soil conditions (e.g., avoid over-fertilization with soluble nitrogen).
- Mow correctly. Set the mower blade high for most turf (5 cm is a minimum, 8-9 cm is better).
- When possible, leave cuttings on the turf to add nitrogen and organic matter. Do not do this during wet conditions and times of excess growth (e.g., early spring).
- Correct soil compaction and poor drainage.
- Irrigate correctly for the soil type and time of year. Avoid shallow, frequent watering. Infrequent, deep watering promotes deep root growth.
- Manage thatch. It Maintain a moderate (1-2 cm) layer of thatch. Note: Thatch is the layer of matted partially decomposed dead leaves and shoots between the base of the turf plant and the soil surface.
- Overseed following any de-thatching operations, bare areas from de-thatching can provide spaces for weed growth.
- Prevent thin areas by distributing foot traffic evenly over the turf surface. Where practical, keep traffic off lawns and turf that is very wet or very dry. Permanent paths should be considered for areas receiving constant traffic.
- Repair and re-seed any thin areas as quickly as possible to avoid weeds an opening.

Identification

It is important to know the weed species present in the area being managed. This information is used to select and plan treatments. Provincial or local weed guides are a useful resource when identifying weeds. See references listed at the end of chapter 8.

Common broadleaf weeds that infest lawns, golf courses and playing fields include:

- Dandelion
- Broad-leaved plantain
- Dock
- Ground ivy
- Hawkweed
- Creeping buttercup
- Prostrate knotweed
- Chickweed

Of these, dandelions are often the easiest to see when not controlled. Bright yellow flowers and large seed heads are unappealing to many members of the public. This chapter outlines an Integrated Pest Management (IPM) program for broadleaf weeds in turf, including dandelions. Grassy weeds such as couchgrass or crabgrass often require different approaches.

Monitoring

Visual Inspections

Yearly checks of low maintenance sites may be enough to tell if sites are in good condition. Sites with higher levels of maintenance may need to be checked twice a year. If dandelions and other visible flowering plants are the main weeds, they are easy to see during bloom. Photographs can be taken during bloom times. These can be compared from year to year. This will let you see if weeds are increasing or decreasing.

Counting Methods

Weeds can be counted using any of the following methods, as discussed previously in this chapter:

- The transect method
- The grid or quadrant method
- Visual estimation

Injury and Action Thresholds

The preferences of site users or customers should be taken into account when setting thresholds. Some people like small flowers mixed in with turfgrass (e.g., violet, prunella, white clover). Others find even a few dandelion flowers unappealing. Weeds such as buttercup in a lawn may be unappealing due to the spreading, upright growth habit. In general, a lawn with 5 - 10% weed cover, may appear "weed free" to most people. It may also be possible to increase people's tolerance to some weeds such as dandelion by mowing more frequently during the bloom period. This removes flower heads and maintains an even green appearance.

Treatments

Physical and Mechanical Controls

Hand Weeding

Hand weeding should be done in a way that disturbs the turf very little. It can be a very effective control method for low weed densities on high value turf such as golf greens and tees. Long handled weeding tools are available and can increase worker comfort when spot weeding.

It is important to note that every opening in the turf allows weed seeds to germinate. When weeds are removed the hole should be filled back in with a mixture of seed and soil.

Flame Weeding

Specialized flame weeding tools or "flamers" are available from some equipment suppliers. Broadleaf weeds are more prone to heat damage than grasses. A heat resistant sheath protects growing tips of grasses. With care and practice, flamers can be passed quickly over weedy turf areas. This will selectively control the broadleaf weeds without damaging the grasses.

Infrared Weeding

Hand-held infrared weeding tools are sold in Canada. These tools can be used to control dandelions and other weeds. They burn propane fuel from a backpack tank. This provides a radiant heat source that is delivered to the plant by a probe. The probe tip is pushed into the growing point of the weed to kill it.

Chemical Control

A number of selective herbicides can be used to control broadleaf weeds in turf. These include 2,4-D, mecoprop, MCPA, dicamba, and mixtures of these. Herbicides should only be used where required. Spot-treating weedy areas instead of using broadcast applications will provide good control.

Herbicides must be applied at the correct time of the year to get good weed control. Knowing the weed populations at your site and their lifecycles will help you determine when to apply herbicides. Always follow the directions on the pesticide label.

Before applying herbicides, consult the provincial regulator for certification, permit, or license requirements. In some municipalities, bylaws on pesticide use may be in place. Consult your municipality for details.

Avoid using combination herbicide and fertilizer products. This spreads herbicide over an entire area each time the turf is fertilized. Weedy and weed-free areas are both treated with herbicide. This goes against the goals of an IPM program. It also causes a great deal of pesticide use that is not needed. In some provinces, public outcry against unnecessary pesticide use on turf has resulted in municipal bylaws that restrict their use.

Evaluation

At the end of each season review all aspects of the IPM program, consider the results obtained and identify changes that can be made to improve the program's effectiveness. Before the next season starts, determine if there are new products and tools that could be used in the program.

Summary

A weed is any plant that is growing in the wrong place. Weeds are a common problem in turf and landscapes. To use an IPM approach, you must be able to identify weeds, know their life cycles, and their biology. Weeds are identified by looking at a number of plant parts. It is important to properly identify weeds and determine their stage of growth before planning control treatments. An IPM program for weeds often begins with dividing the area to be managed into categories or classes based on the level of weed infestation that can be tolerated.

Weeds are then monitored and controlled using a variety of methods including:

- **Cultural (e.g., correcting growing conditions, over-seeding)**
- **Physical (e.g., hand weeding, use of flame or infrared weeders)**
- **Chemical (e.g., herbicides)**

Self-test Questions

Answers are located in Appendix A of this manual.

Self-test questions for chapters 5, 6, 7, and 8 can be found at the end of chapter 8.

Chapter

8

DISEASES AND DISORDERS

Landscape and turf plant damage can result from many causes such as insect feeding, equipment injury, heavy use, growth disorders and infection by disease organisms. Growth disorders occur when plants are grown with incorrect amounts of water, nutrients, or light. Temperature extremes can also cause growth disorders.

Plant diseases caused by pathogens are called infectious diseases. These diseases can be hard to diagnose and treat. They are caused by organisms that are too small to see with the naked eye. Microorganisms that infect plants are called plant pathogens. Pathogens include fungi, bacteria, viruses, and nematodes. When they infect a plant, they change the way in which it functions. They can kill or stunt the plant. A disease is passed from plant to plant as the pathogen multiplies and spreads.

Plant diseases and disorders are both common in turf and landscape plants. Distinguishing between plant diseases, disorders and other forms of damage is the first step in developing an IPM program. When faced with plant damage, it is often easiest to rule out insect feeding and environmental causes first.

To plan an IPM program for plant disease organisms (pathogens), you must know their life cycle and biology. It is also important to know the type of treatments that are available and how they work. The following section provides information on:

- Plant disorders
- The biology of plant pathogens
- The treatments that can be used for plant disease

The final section outlines a sample IPM program to manage pink snow mold on turf.

Learning Objectives

Completing this chapter will help you to:

- **Know common diseases. Know how to manage them using IPM.**
- **Know the types of fungicides. Give an example of each.**
- **Know what affects the effectiveness of fungicides.**

Disorders

A variety of environmental conditions can cause plant disorders. Poor environmental conditions stress plants and cause abnormal growth or disease-like symptoms.

The cause of plant symptoms must be identified in order to choose a proper treatment. Treat plant disorders by changing the conditions that caused the damage (if possible).

Conditions that cause plant disorders include:

- Air pollutants
- Toxic chemicals (including road salt)
- Pet urine
- Temperature extremes (hot and cold) or wind
- Lack of light, water or soil nutrients
- People pressures (heavy use, soil compaction)
- Damage by equipment (e.g., string trimmer damage to trees, mower damage to golf greens)

Knowing recent weather conditions can help in identifying whether plant damage is caused by environmental factors or a pathogen. It is important to identify and correct the conditions that cause disorders.

Diseases

Plant disease is often caused by a combination of environmental conditions and pests. Plants already weakened by environmental stress are more likely to be attacked by pathogens or insects. For example, wood boring insects often attack weakened trees. Stressed plants sustain more damage and heal more slowly from any type of damage. Removing the source of the stress improves plant appearance in landscapes. It also helps them to resist pest attacks.

Fungi, bacteria, and viruses are microorganisms that can cause plant disease. Nematodes (microscopic worms) that damage plants are also covered in this section. There are also many beneficial microorganisms. Some beneficial fungi, bacteria, and actinomycetes (soil organisms that are similar to fungi and bacteria) help plants resist disease. Others attack pathogens and nematodes that cause disease.

Fungi

Fungi are the largest group of organisms that cause plant disease. These include the molds, rusts and mushrooms. Fungi do not have chlorophyll. They obtain nutrients by breaking down other materials or organisms.

- Saprophytic fungi feed on dead or dying plants. The majority of species in this group of fungi are beneficial decomposers

- Parasitic fungi feed on living plants. Species in this group can cause disease in desirable plants.

Life Cycles of Fungi

Most pathogenic (disease-causing) fungi grow and reproduce on one host plant. Some require a second host plant to complete the life cycle (e.g., many species of rusts). Cedar apple rust passes between cedar and apple trees to complete its life cycle.

The life cycles of most fungi starts with an over-wintering spore. These spores are often found in the soil or on diseased leaves and in leaf litter on the soil surface. Spores are carried to new host plants on equipment, or by irrigation water or rain. If the temperature, moisture, and host plant are suited for fungal growth, the spores can germinate and infect the plant.

Spores can die if environmental conditions do not support germination (e.g., too hot or cold, very dry). They can also be washed off plants before they germinate. Some spores can remain dormant until conditions improve.

When conditions are right and a spore lands on the leaf, it germinates and sends out **hyphae** (fine strands of fungus). The infection begins when the hyphae enter plant tissue and grow within the plant. The fungi grow and produce the next generation of spores. The spores are released and carried to other plants by wind, rain, or splashing water. Some can be carried on the feet of birds moving between trees (e.g., black knot on cherry). Spores or tiny fungal pieces can be spread by moving infected plants, plant parts, tools, machines, humans, animals, and soil. Fungal diseases are managed through the use of preventative practices, sanitation (removal of diseased plants or plant parts) and the use of fungicides.

Bacteria

Bacteria are single-celled microorganisms. Plant pathogenic bacteria often enter plants through natural openings or wounds. Major bacterial plant diseases include leaf blights, wilts, leaf spots, galls, and root rots.

Bacteria reproduce quickly under the right conditions. The plant is used as a food source. Reproduction is affected by temperature and humidity. Bacteria are spread by:

- Rain
- Ground or surface water
- Animals, insects, or equipment

Bacterial diseases must be managed by sanitation and prevention. Very few can be controlled by bactericides.

Viruses

Viruses (and mycoplasmas) are very small organisms. They cannot be seen with an ordinary microscope. Viruses cause diseases that can reduce plant vigour or kill them. Viruses must reproduce within living cells. Viruses can be spread by:

- Mechanical means (e.g., carried on tools during pruning)
- Propagation material (e.g., seeds, tubers, and other plant parts)
- Other organisms (vectors) such as some sucking insects and nematodes.

The symptoms of viral diseases can be very striking. They include:

- Wilting
- Mottling
- Streaking and discolouration of leaves and flowers
- Abnormal growths

No pesticides directly control viruses. Pesticides can be used to control the vectors of viruses. This will reduce the risk of infection. To manage plant viruses, choose virus-resistant cultivars and apply strict sanitation methods to prevent the spreading of a virus to other plants.

Nematodes

Nematodes are microscopic worm-like organisms. Some very tiny species feed on plant roots, stems, and leaves. Others are essential soil decomposers or beneficial parasites of insects. Infection by plant pathogenic nematodes can affect movement of water and nutrients within a plant. They can also make wounds in roots that allow fungi or bacteria to enter. Symptoms of nematode damage include:

- Wilting
- Leaf drop
- Stunting
- Lack of vigour
- Growth deformities in roots, shoots, and leaves

Nematodes reproduce by producing eggs. Both eggs and nematodes move through soil on a film of water. They can also be transported in contaminated soil, water, containers and equipment. Nematodes can be controlled with nematicides, however they are not widely used in the Landscape industry.

Developing an IPM Program for Plant Diseases

The following section outlines a general IPM program for plant diseases. It includes the following steps: prevention, identification, monitoring, injury and action thresholds, treatments, and evaluation. For more information on IPM, see **Chapter 5** above. Also see the **Applicator Core Manual Chapter 7: Integrated Pest Management**.

Healthy, well maintained plants can often defend against infection. As well, if healthy plants become infected they may recover from disease more quickly. In an IPM program, all plant health factors are checked and corrected, if necessary.

For a plant disease to develop, three things must be present. These are:

- The disease-causing organism (pathogen)
- A host plant that is susceptible to the pathogen
- Environmental conditions that favour pathogen growth

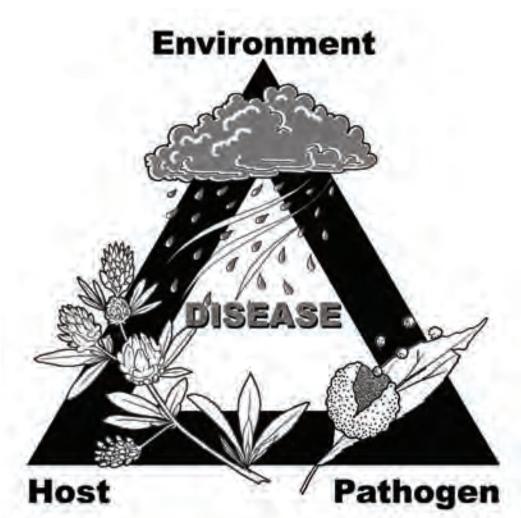


Figure 8-1: The plant disease triangle.

The plant disease triangle **(Figure 8-1)** illustrates this concept. All three sides of the plant disease triangle must be present for disease to occur. Remove one or more of the sides of the disease triangle to prevent plant diseases.

An IPM program for plant diseases should include prevention, identification, monitoring, injury & action thresholds, treatments and evaluation.

Prevention

In general, prevention methods create conditions that are not favourable for the development of plant diseases.

- **Remove the pathogen.** Use sanitation to keep pathogens out of an area. Reduce the presence of infectious spores or other stages:
  - Inspect plants for signs of disease before buying them. Buy only healthy plants. This avoids bringing disease into a landscape.
  - Remove alternate host plants.
  - Rake up and destroy diseased leaves and other plant parts (e.g., from black spot-infected roses or scab-infected ornamental apples).
  - Prune out and destroy infected plant material (e.g., branches with black knot).
- **Avoid susceptible host plants.** Choose disease-resistant cultivars or plants not affected by diseases. This should be considered for all new plants and replacement plants in landscapes. For example, hardy disease-resistant rose cultivars can be chosen to replace susceptible cultivars in display beds.
- **Make the environment less favourable to the pathogen.** Grow seedlings in warm conditions to slow the spread of damping-off diseases. Pruning plants promotes good air circulation among branches and allows leaves to dry more quickly. This removes moisture that most fungal and bacterial spores need to germinate. Avoid over-watering and correct poor drainage to reduce root diseases. In high maintenance turf areas (e.g. sports fields and golf greens) correct soil compaction and damage caused by turf wear. Both make the turf more susceptible to disease. Time irrigation practices to allow the turf canopy to properly dry out each day. Prolonged periods of leaf wetness can contribute to disease problems.

Identification

Plant diseases are often hard to diagnose. Symptoms may look like damage caused by:

- Insects or mites
- Herbicides
- Disorders (described previously)

Many diseases have similar symptoms. This makes identification of the pathogen difficult.

You may need to watch affected plants in the landscape for a number of days or weeks. Changes in symptoms can help with diagnosis. Knowing weather conditions (temperature and rainfall) in the weeks before symptoms appear can also be helpful when diagnosing fungal diseases. To make a proper diagnosis, collect affected leaves or plant parts. These must be examined with a hand lens or under a microscope. A plant pathologist may be needed to diagnose the problem.

Monitoring

Some diseases develop quite slowly, disease development can be monitored over a period of time and treatment decisions can be made. Other diseases develop very rapidly. When symptoms of plant disease are visible, it may be too late to control it. Pathogens inside the plant tissue may not be susceptible to treatments. Monitoring for rapidly developing disease includes looking for the conditions that allow plant pathogens to develop and spread. When conditions are favourable for disease development, plants should be checked regularly for the first signs of disease. A working understanding of the biology of the diseases common to your area and the plants that you manage is critical to planning an effective monitoring program.

Visual Inspections

Using a hand lens and other tools (e.g., shovel, soil probe, pocket knife), inspect foliage, soil and roots.

Look for conditions that allow pathogens to enter plants, such as:

- Cuts or scrapes to bark or foliage

- Poor growing conditions that injure roots (e.g., compacted, waterlogged or dry soil)
- The presence of sucking insects

Look for signs and symptoms of disease, such as:

- Wilted, distorted or abnormally shaped shoots and leaves
- Spots, streaks or discolourations on leaves, stems or flowers
- Discoloured or damaged roots
- Reproductive structures of fungi or fungal growth

Weather Records

Different pathogens need different climate conditions to germinate and grow. Keep records of humidity, temperature and rainfall when plant diseases are expected to be most active. These records can be helpful in identifying the conditions that are favourable for the development of fungal and bacterial diseases. This allows closer monitoring or application of protective treatments to be planned.

Assessment Methods

To measure the progress of a plant disease, the number of diseased leaves, plants, or areas of infected turf must be assessed on a regular basis. These assessments may not be as useful in landscapes as keeping track of weather. Most landscapes include a variety of plants. Most pathogens only attack one or a few plant species. The spread of disease is often limited. If there are a large number of susceptible plants in the landscape, counting infected plants or plant parts may be useful because it shows if the disease is spreading. Percentage estimates are often used to assess the amount of damage in specialty turf (e.g., golf courses, sports fields).

Injury and Action Thresholds

It is difficult to develop general information on injury thresholds. Injury levels are often site specific. They can depend on how much damage site users will accept. For plant disease, injury levels also depend on risks to the long-term health of the plant. The risk of the disease spreading must also be taken into account.

Injury thresholds for disease can be based on the proportion of damaged leaves on a given plant, the number of affected plants on a site, or the percent of area affected (e.g., turf or leaf canopy).

Action thresholds depend on the planned treatment. For example, most fungicides prevent the pathogen from infecting healthy tissue. These are not meant to kill the pathogen once it is in the plant. On high-risk plants, these fungicide applications might be used when weather conditions favour disease development and there is a history of disease problems in the area. Landscape managers often factor in the past history of disease at the site when deciding to treat or not. This is only possible when good records are kept.

Treatments

Physical and Mechanical Controls

In some cases, (e.g., diseases on ornamental plants) you can effectively treat the disease by removing the infected plant or plant part.

Chemical Control

Fungicides, bactericides and nematicides are pesticides that are used to kill, prevent or alter the growth of plant pathogens. These can be natural or synthetic. Fungicides are used to control plant diseases caused by fungi. Individual fungicides may control some plant diseases, but not all. Bactericides are used for sterilizing tools to help prevent the spread of bacterial diseases. Nematicides (soil fumigants) may be used on rare occasions. **The use of soil fumigants is not covered by a landscape applicators certificate/license. You must obtain a fumigation certificate/license to apply fumigants.** Herbicides may be used to remove weeds that serve as reservoirs for pathogens.

Characteristics of Fungicides

Fungicides kill fungi, prevent their spread, or protect plants from infection. Fungi are most susceptible to fungicides at the incubation stage of their life cycles.

Dormant and over-wintering fungal spores are resistant to fungicides. Fungi are also difficult to control once they are inside the plant tissue. At this point, they are protected. A systemic fungicide may keep the disease from spreading to other parts of the plant. To be effective, it must be applied before infection is too severe.

Many fungicides are selective, meaning that they control some diseases but not others. To get good disease control, it is essential to correctly identify the disease-causing organism.

Fungicides are classified as follows:

- **Contact fungicides** (also called protectant fungicides) are applied as a film on the plant leaves and stems. They prevent the fungal spores from germinating. Contact fungicides must be applied before the fungus infects the plant. These fungicides can protect the plant from infections. They often do not kill the fungus inside the plant. New plant growth that appears after treatment is not protected. A number of applications are required. Contact fungicides may be applied to turf and to the leaves, stems and flowers of landscape plants. These are the most widely used type of fungicides. Examples include mancozeb and thiram.

- **Systemic fungicides** are absorbed into plants. Once in the plant, they move within plant tissues. They often act to protect against infection. Systemic fungicides may kill fungi that are already established within the plant. These are called **eradicants**. Once inside the plant, systemic fungicides move to new areas of plant growth. Examples include triforine and benomyl.

FACTORS AFFECTING FUNGICIDE EFFICACY

The effectiveness of a fungicide in controlling disease depends on:

- **Timing of application**: The fungicide should be on, or in the plant before or during the early stages of infection. If the fungicide breaks down quickly, it may have to be applied more often.

- **Fungus life cycle:** Timing of application(s) depends on the type of fungus. If the fungus has a short life cycle, it may have many infection periods in a growing season. Frequent applications may be needed.

- **Rate of plant growth:** Fungicides must be applied to protect new growth. As new leaves grow, more applications may be needed.

- **Weather:** The timing of fungicide applications can vary with environmental conditions. If the weather does not favour fungal growth, fewer applications may be needed. Rain can wash off a fungicide. A repeat application may be needed.

- **Fungicide Resistance:** Some pathogens can develop resistance to certain fungicides or groups of fungicides. Disease organisms can become resistant after repeated fungicide applications. See **Applicator Core Manual** for more information on resistance. To prevent or delay resistance, alternate fungicides with different modes of action.

BACTERICIDES

Bactericides are pesticides that are toxic to bacteria. They kill bacteria on contact. They must be used before bacteria infect a plant.

The effectiveness of bactericides depends on the application timing, weather, and the amount of bacteria present.

NEMATICIDES

Nematicides are pesticides that control nematodes. Some nematicides act through direct contact with the nematode. Others can act systemically when nematodes feed on a plant and acquire a lethal dose. Nematicides are rarely used in landscapes, but they may be used to disinfect nursery soils.

Evaluation

At the end of each season review all aspects of the IPM program, consider the results obtained and identify changes that can be made to improve the program's effectiveness. Before the next season starts, determine if there are any new products and tools that could be used in the program.

In Review

Landscape and turf plants can be damaged by insect feeding, equipment injury, heavy use, growth disorders and infection by disease organisms. It is important to distinguish between plant diseases, disorders and other forms of damage when developing an IPM program.

Fungi, bacteria, and viruses can cause plant disease. Nematodes (microscopic worms) damage plants. For a plant disease to develop, the pathogen, a susceptible host and environmental conditions that favour disease development must be present. Diseases can often be prevented by affecting one of these factors. It is often easier to prevent diseases than to control them. In an IPM program, plant diseases are monitored by watching for weather conditions that favour disease development and by looking for disease symptoms. Fungicides, bactericides and nematicides are used to kill, prevent or alter the growth of plant pathogens. Fungicides can be classified as contact or systemic. A number of factors affect fungicide effectiveness. These must be considered when planning applications.

A Sample IPM Program for Diseases

This section outlines an IPM program for a common turf disease called pink snow mold. It is caused by the fungus *Microdocium nivale*; formerly called *Fusarium nivale*.

Description of Pink Snow Mold

This disease can occur with or without snow cover. In cooler, coastal areas of Atlantic Canada, pink snow mold can occur at almost any time during the year. When it occurs without snow cover, the disease is usually called "Fusarium patch".

Under snow, infected turf is covered with patches of white, fluffy, fungal growth. This growth turns salmon pink when the snow melts and sunlight reaches the fungus. The pink colour comes from spores produced in response to sunlight. The patches later become bleached and eventually turn brown.

The fungus mainly infects the leaves of turf grasses starting with the lower leaves. It may attack stems. If leaves are damaged a number of times, roots and crowns may become weak and die.

Biology and Life Cycle

The pink snow mold fungus (*M. nivale*) lives in living plant tissue and plant debris (e.g., thatch). It infects leaves when temperature and relative humidity are favorable. Disease progress is slow at first. Leaves begin to turn brown two or three weeks after infection. The disease is spread quickly by spores when conditions are right.

The fungus may be active all year round. It does the most damage from fall through spring (wet, cold weather). Turfgrass is most at risk when it is growing slowly or dormant. Infections can occur from 0^0 to 31^0 C. Most occur below 16^0C. Turf that is snow-covered, but not frozen, is ideal for the disease to spread. Other conditions that promote spread are:

- Repeated frosts
- Alternate freezing and thawing

- Drizzling rain
- Cold fog

Prevention

Some fescue cultivars are less prone to pink snow mold than other grasses. Check with local turf seed vendors. They can recommend grasses suited to the region that is more resistant.

The following will also help prevent or reduce infection:

- Mow and remove clippings in the fall until turf growth stops. Rake any leaves off the turf. Going into the winter, turf should be short with little dead plant material.

- Remove brush, bushes, or fences that cause snow to pile up. This may cause localized winter kill during extreme cold winters.

- In winter, prevent compacting of snow on the turf by snowmobiles, skiing, etc.

- When snow begins to melt in early spring, remove any large piles or drifts.

- Leave some snow cover on the turf.

- Use a balanced fertilizer. Avoid heavy applications of nitrogen, especially late in the year. Highly water-soluble nitrogen applied in late fall promotes growth of soft, succulent leaves. These are at risk of attack by the fungus.

- The disease is most severe where trees and shrubs shade the turf and block movement of air. Prune trees and shrubs to increase sun and air circulation.

- Spores and infected leaves can be moved on shoes, mowers, and other equipment. These can spread disease to uninfected areas. When working on the turf, work in infected areas last. Clean all equipment before using it on other areas.

Monitoring

Pink snow mold shows up as brownish-pink patches of damaged turf. In wet conditions, small tufts of fluffy, white fungal growth (mycelia) may be seen at the edge of the patches. To identify pink snow mold, look for tinges of pink or orange colour on blades of grass plants. When magnified, spores appear as salmon-pink clusters on leaves.

Check for signs of disease in the fall, as the weather becomes colder and wetter. Look again in the spring as the snow begins to melt.

Injury and Action Thresholds

The establishment of injury and action thresholds must be done on a site by site basis. Thresholds should consider factors such as forecast and typical spring weather conditions, location of the site, type of soil or media, drainage and other factors. If turf heals quickly in the spring with little damage, no treatment is required. ***See cultural practices under Prevention section*** above for ways to prevent the fungus in the future.

Treatment

Chemical Controls

Fungicides are often may be used to control this disease if it regularly causes severe damage. Monitor for the first signs of disease in the fall. Apply fungicides when conditions promote the growth of the fungus but before the first snow fall. Resistance to fungicides is a problem in some areas. Alternate fungicide types to reduce the build-up of resistance.

In Review

Pink snow mold occurs throughout the Atlantic Region. This disease can be a problem on high value turfgrass such as golf greens. It is rarely a problem on lawns and other turf areas. The fungus can infect the leaves of turfgrass when cool wet conditions exist. Severe damage may involve the roots and crowns. Prevention is the best way to control this disease. Some fescue grass cultivars are less susceptible to this disease. Where appropriate, these should be used in areas prone to snow mold. Mow and remove clippings in the fall until turf growth stops. Prevent traffic and compaction during the winter. Remove large piles or drifts of snow. If it appears in one turf area, avoid spreading the disease to other areas. Save this area for last when working.

Summary

Landscape and turf plant damage can result from many causes such as insect feeding, equipment injury, heavy use, growth disorders and infection by disease organisms. Growth disorders occur when plants are grown with incorrect amounts of water, nutrients, or light. Temperature extremes can also cause growth disorders.

Plant diseases caused by pathogens are called infectious diseases. With infectious diseases, new plants can become infected when the disease-causing organism is spread to them. Several groups of organisms cause plant diseases including bacteria, viruses, nematodes, and fungi.

Plant disorders are treated by changing the conditions that caused the damage (if possible).

To plan an IPM program for plant disease organisms (pathogens), you must identify the pathogen and know its life cycle and biology. Prevention is the corner stone of an IPM program for plant diseases. Healthy, well-maintained plants can often defend themselves against infection and may recover from disease more quickly if they become infected. If treatment is required it is important to understand the nature of treatments and how they work.

A sample IPM program for pink snow mold demonstrates how the parts of an IPM program can be used to control a common turf disease.

Self-test Questions for Chapters 5, 6, 7, 8

Answers are located in appendix A of this manual.

1. Give two examples of realistic objectives when starting an IPM program for the first time.

2. What information should be gathered to prepare for an IPM program?

3. Why are sticky traps for insects often not a good outdoor monitoring method?

4. What are two main ways to use natural enemies of pests in an IPM program?

5. How do horticultural oils affect insects and mites?

6. Why are selective pesticides the better choice for an IPM program if a pesticide is needed?

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7. List three ways to prevent weed problems.

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8. Why must you diagnose and correct if possible, environmental conditions that cause plant disorders?

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9. What fungal stage is least likely to be affected by a fungicide?

____

10. The life cycle of an insect species with complete metamorphosis includes egg, larva, pupa, and adult. **True or false**?

11. Insect growth regulators attract beneficial insects to plants attacked by pests. **True or false**?

12. You must remove at least two sides of the "disease triangle" to manage plant disease. **True or false**?

Chapter

9

APPLICATION TECHNOLOGY

The goal of a pesticide application is to apply the pesticide evenly to the desired target at the recommended label rate. Contamination of non-target areas should be avoided. To do this, choose the proper application equipment for the job and understand how it works. Make sure that equipment is used, calibrated, and maintained properly. This chapter deals with selection of sprayers and granular application equipment. Calibration, calculations and environmental conditions during an application are also covered.

Learning Objectives

Completing this chapter will help you to:

- **Know the basic parts of common types of application equipment. This ensures proper selection and use.**
- **Understand that calibration ensures that correct amounts of liquid or granular pesticides are applied.**
- **Know basic procedures for cleaning and maintaining liquid and granular application equipment.**
- **Know the effect of environmental conditions on common types of application equipment.**
- **Know how to calculate the correct amount of pesticide required.**

Liquid Application Equipment

You must choose proper equipment and understand its parts. This ensures that pesticide particles or droplets reach the target pest. The following section describes common equipment used in landscape and turf pest management.

Equipment Selection

The Application equipment used in landscape pest management can be placed in one of two groups based on whether a liquid or granular formulation is applied. In both cases, the aim is to apply the correct amount of pesticide to the target with maximum effect and minimum off-target movement.

The type of equipment chosen to apply pesticides depends on:

- The type of pesticide to be sprayed
- The rate and pesticide formulation
- Label recommendations
- The size and location of the treatment area
- Distance from sensitive areas
- The pest

Hand-held Pressure Sprayers

Hand-held pressure sprayers are often used to treat small areas. The sprayer contains a small tank. Applications are made from a small hose with a single nozzle. The sprayer handle is pumped to build up pressure in the tank. Droplet size and density varies. This depends on tank pressure and type of nozzle used.

Backpack Sprayers

Backpack sprayers are often used to treat small areas. The sprayer has a small tank strapped to the applicator's back. Applications are made from a small hose and single nozzle. The applicator pumps the sprayer handle to build up tank pressure. Some backpack sprayers have small motors to create pressure. Droplet size and density varies with the pressure in the small pressure chamber.

Boom Sprayers

Boom sprayers have a number of nozzles evenly spaced over the length of the boom. Most boom sprayers are horizontal. A pump creates pressure to bring the spray mix to the boom. Droplet size and spray density is controlled by changing pump pressure and choosing the proper nozzle type. Boom sprayers are often used on municipal parks, golf courses and sports fields. They are commonly used to apply spray liquid herbicides.

Power Hose Sprayers

Power hose sprayers have parts that are similar to motorized boom sprayers. Spray is spread onto vegetation through one or more hose spray guns. Many hand sprayers, small power sprayers, and mist blowers have the spray gun built in as part of the sprayer or supplied as standard equipment.

Spray guns may have a shut-off valve and nozzle. This may be in two parts, or one unit that combines both functions. Spray guns come in a wide range of models and sizes. They can be made of plastic, brass, aluminum, stainless steel, or a combination of these. The material that you choose depends on:

- The pesticide spray mixture
- Required pressure
- How often the guns are used

Some guns are rated for pressures between 200 and 5,000 kPa. Others are rated for different pressure ranges or pressures less than 1,500 kPa. Select the one that best matches the sprayer operating pressure. Spray gun nozzles must be set to deliver spray at the proper volume, angle and distance. Some nozzles can be adjusted to produce patterns ranging from solid streams to fine cone sprays.

The hose is often stored on a powered reel mounted on the spray vehicle. These sprayers may have high-pressure pumps that can send spray (above 1.5 metres) to tree height or through thick foliage.

Spray gun types include the following:

- **Hand Held Spray Wand**: Hand held spray wands are most commonly used for lawn spraying. The nozzle is held close to the ground (30-45 cm). A flat fan spray nozzle pattern is often used with different spray widths and flow rates. Nozzle tips can be changed.

- **Handgun-Type:** Handgun-type spray guns are used in a number of situations. This includes the spraying of large trees, shrubs, greenhouses, and lawn applications. Most handgun-type spray guns have a 'shower head' type nozzle. These have a number of holes, depending on required flow rate and droplet size. This type of spray gun gives excellent coverage on coarse textured surfaces such as a shrubs or tree canopies. Handgun-type spray guns can spray long distances in applications more than 3M above ground (e.g., tall tree canopy). Hand held tree guns have special nozzles with high flow rates and a solid stream spray pattern.

- **Boom-Type**: Boom-type spray guns have a wand with a spray boom at a right angle on the end. They have a number of nozzles to cover a wider area. Flat fan spray nozzles with a slight overlapping spray pattern are often used. Boom-type spray guns are used for large area applications. They can be mounted on equipment (e.g., tractor) or hand-held. Large hand-held boom-type spray guns often have flotation wheels to support their weight.

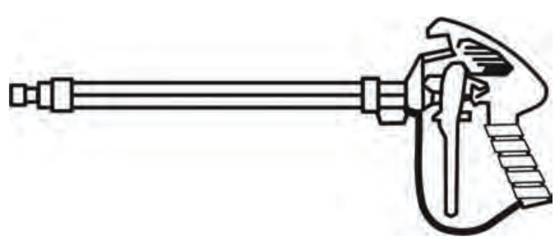


Figure 9-1: Power hose sprayer: Hand-held spray wand.

Air-Blast Sprayers

Air-blast sprayers are often used on orchards, grapes and blueberries. Air-blast sprayers have tank sizes from 400-3000 litres. Air-blast sprayers do not have a boom held over the target. Nozzles are placed in a high-speed air stream produced by a fan. The air stream sends the fine spray droplets to the target. The air stream also creates leaf movement. This allows better coverage of insecticides and fungicides. Air-blast sprayers can be used to treat large ornamental trees in parks and golf courses.

Wick Application Equipment

Wick application equipment is used where targets are very specific or no drift can be tolerated. A tank is connected to a wick. The wick absorbs and holds spray mix. The applicator wipes the wick across the pest species. Wick applicators are often used to apply non-selective herbicides to selected weeds when sensitive plants are growing nearby.

Tree Stem Injectors

Some equipment injects pesticide into tree stems. Systemic pesticide is injected under the bark and into the tissues. It then moves up into shoots or down into roots. Injection equipment may include a tool to cut through the bark and manually operated sprayer. This could be a hatchet and backpack mounted pressure sprayer. Lance injectors are also common. The lance both cuts through the bark and injects pesticide into the tree just below the bark.

Brush Saw Application Equipment

A small herbicide reservoir is attached to the bottom of the brush saw. A pump and dispensing system are active during the saw's brush cutting action. Brush is cut and sprayed at the same time. This improves the herbicide's movement through the cambium layer. This application equipment is very selective. It does not produce drift.

Granular Application Equipment

Granular application equipment is used to apply granular pesticides. Types of granular application equipment include gravity broadcast, centrifugal, and airblast.

Gravity Broadcast

Gravity broadcast spreaders meter pesticide granules out using paddles. The granules fall through adjustable slots and are dropped to the ground. Application uniformity is affected by granule size, ground speed, humidity, turns, and rough ground conditions.

Centrifugal

Centrifugal spreaders meter pesticide granules out through a rotary paddle distributor. Application uniformity is affected by ground speed, and wind.

Airblast

Airblast spreaders meter pesticide granules into a high volume air stream generated by a powered fan. This is usually done from a ground drive. Airflow transports granules through hoses and flow divider pots to individual outlets. This is more accurate than gravity broadcast and centrifugal systems.

In Review

There is a variety of equipment for landscaping. These include backpack sprayers, air blast sprayers, and brush saw applicators. Applicators must choose the best type for the job based on:

- **The pest**
- **The pesticide**
- **The treatment area**
- **Distance from sensitive areas**
- **How the equipment works**

Basic Components of Motorized Sprayers

Applicators need to know how the parts of a sprayer work together to deliver the right amount of liquid pesticide. This information is used to calibrate and fine-tune the equipment. This section describes how the parts of a sprayer work.

Spray Tanks

The spray tanks hold the spray mixture. Tanks come in a number of shapes, sizes and materials. Choose a tank that is strong, resists corrosion, and will not react with the pesticides being used. Tanks should have graduated markings. They should be equipped with baffles to prevent sloshing. The tank shape should promote agitation. The tank should be easy to fill, clean, and drain completely. Oval and cylindrical tanks are common. Rectangular and flat-bottomed tanks are harder to agitate and clean. Tank size should suit the sprayer boom width and output.

Pumps

Pumps move the spray from the tank to the nozzle. They may be powered by a number of means. Choose a pump that is suited to move the pesticide and carrier to be used.

To choose a pump that will provide required output and pressure, determine:

- The number and output of nozzles
- The extent of agitation
- Whether bypass filtration is required

Pump flow capacity should be 20% greater than needed. This ensures proper pressure and flow over time as the pump wears. A properly sized pump will allow for an increase in travel speed or an increase in the number of nozzles on the boom if needed.

Pump type affects the controls needed. Refer to the pump manufacturer's instructions for details. Piston and diaphragm pumps require a pulsation damper to reduce pressure changes. Roller pumps can wear quickly. They are not advised when using abrasive formulations.

Agitators

Agitation mixes the pesticide with the carrier (usually water). It prevents suspended pesticides from settling out. The amount of needed agitation depends on the type of formulation used. Proper agitation must be used when applying pesticides. Under and over agitation can reduce pesticide performance.

Mechanical and hydraulic agitation systems are common. Mechanical systems use paddles to stir the contents of the tank. Hydraulic systems use special agitation nozzles in the tank. This creates spray mixture movement. More pump capacity is needed for hydraulic agitation.

Strainers

Strainers keep debris and un-dissolved pesticides in the spray mixture from damaging the pump or plugging the nozzles.

Strainers can be installed in the following locations:

- The tank opening (prevents debris from getting into the tank during filling)
- Between the tank and pump (protects the pump from damage)
- After the pump (keeps fine particles from getting into the spray lines)
- In the nozzle body (prevents the nozzle from clogging)

Coarser mesh strainers should be at the tank opening. Finer mesh strainers are used at the nozzle. Smaller nozzles require finer strainers. More coarse strainers are needed to use wettable powders or flowable formulations. Follow the manufacturer's guidelines on strainer size needed to protect nozzles and pumps.

Permanently removing the strainers is not a good way to solve clogging problems. Strainers protect sprayer parts and should not be removed. If there is repeated clogging, you may need to change the type of pesticide formulation used.

Controls

Control systems can be manual or electronic. There are two common control systems:

- Pressure control systems use a pressure-regulating valve (PRV). This maintains a constant operating pressure. These are often found on hand-held and backpack equipment.

- Volume control (volumetric) systems allow operating pressure/nozzle output to vary with travel speed/engine RPM. These are often found on boom and airblast sprayers.

Spray monitors may further improve the application of pesticides. They give the operator more information.

Plumbing

The size of hoses and fittings affect system capacity and pressure. Under-sized hoses and fittings can reduce pump capacity. Suction hose diameter should be at least as large as the pump intake opening. Flow restrictions can create a drop in pressure. This can cause uneven nozzle output and irregular spray pattern. Uneven nozzle output can also be caused by changes in flow or variations in hose length along the boom.

Flow may be restricted by:

- Under-sized boom plumbing
- Under-sized controls or fittings
- Kinked hoses
- Under-sized or clogged strainers

Hoses and fittings on the pressure side of the pump must be able to handle the maximum pump pressure. These must also be able to withstand pressure surges.

Boom Design

The boom supports and supplies spray mix to the nozzles. The boom should have end caps to allow flushing of the boom and nozzles. Design and use of the boom can affect application uniformity.

Sprayers should be used at travel speeds that reduce boom movement. Too much boom movement during application can cause uneven spray coverage. It can also damage the boom. Booms should also have support. Suspension systems may support the sprayer chassis and/or boom. These can reduce boom movement. When spraying in strips or bands, nozzles should be aligned to cover the area evenly. They should be arranged to avoid skips or overlaps between passes of the sprayer.

Pressure Gauges

Pressure gauges measure the operating pressure. They are used before spraying to set the sprayer to the desired pressure. During the application, gauges should be watched for changes in pressure. These can indicate problems. Gauges should measure pressure near the nozzles. Gauges should be checked for accuracy. Adapters are available to attach pressure gauges to nozzle bodies. These can be used to spot-check nozzle pressure and find pressure drops along the sprayer's plumbing.

Gauges can be liquid-filled or dry. Liquid-filled gauges dampen pressure pulsations. This gives a steadier reading. They also respond slower to changes in pressure. Pulsation dampers can be used on dry gauges. Gauges should give pressure in commonly used units (psi, Kpa, bar).

The maximum pressure given on the gauge should be roughly twice the proper operating pressure. This allows accurate reading of pressure. If the pump can produce higher pressures than the gauge can read, ensure that there is enough pressure relief to prevent damage to the gauge.

Nozzles

The main functions of a nozzle are:

- Metering (measuring) the amount of spray delivered (nozzle output)
- Atomizing (breaking up) liquid into droplets
- Dispersing (scattering) droplets in a given pattern

A nozzle is made up of a nozzle body, a strainer, a tip, a cap and one or more washers. The nozzle body holds the strainer and tip in place. The cap is used to secure the strainer and tip to the body. The nozzle screen or strainer catches any debris that can clog the nozzle. The nozzle tip helps create the spray pattern. Rubber washers prevent leakage.

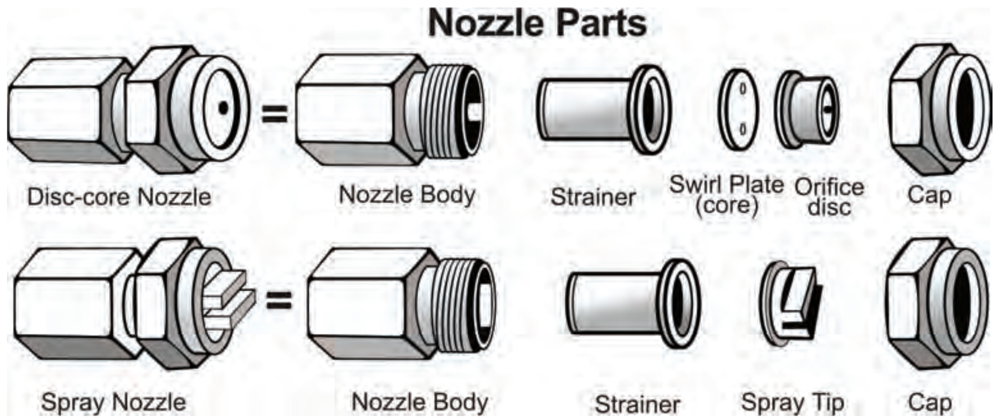


Figure 9-2: Parts of typical nozzles.

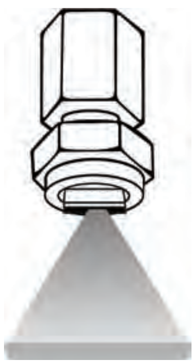
Nozzles come in a range of types, sizes and materials. They are classed by spray pattern. Nozzles on some hand-held or backpack sprayers can be adjusted for flow rate, droplet size, and spray pattern. Most other sprayers use non-adjustable nozzles. These must be changed to get different flow rates or patterns. Pesticide labels may call for certain types and sizes of nozzles (and droplet sizes). Follow label directions. Nozzle types come in a number of nozzle outputs (L/min) and spray angles.

Spray Angle

Nozzle spray angle is the angle formed by a single nozzle at a given pressure. Spray angle varies with pressure. Nozzles can be purchased in a number of standard spray angles. The angle specified by the manufacturer is only obtained when pressure is in the recommended range.

The most common flat fan nozzle angles are 650, 800 and 1100. For a given nozzle type, wider angles decrease droplet size. This assumes that pressure and nozzle output remain constant. Wider nozzle angles may give an even application with lower boom heights. Proper boom height depends on the spray angle and nozzle spacing. Refer to the nozzle manufacturer or provincial guidelines on the required amount of overlap to get an even application.

Flat Fan Nozzles



Flat fan nozzles are often used for herbicide a applications. These provide good application uniformity. Flat fan nozzles are used at low pressures (usually between 100 and 400 kPa).

Tapered edge flat fan nozzles are the most common flat fan nozzles. These produce an oval pattern with tapered edges. Spray patterns should overlap to achieve uniformity. For example, one nozzle spray angle can overlap the next nozzle spray angle. Offset the tapered flat fan nozzles slightly (5-10 degrees) from the boom. This prevents spray interference that can reduce uniformity.

Figure 9-3: Flat-fan nozzle.

Even flat fan nozzles are available for banding applications. These should not be overlapped with other nozzles. Low pressure, pre-orifice, and air-induced flat fan nozzles use reduced pressure and liquid turbulence. This creates coarse sprays. These nozzles reduce drift by 50 to 90%. Minimum operating pressures are often higher than those of conventional nozzles.

Boomless Nozzles

Boomless nozzles are used singly or in clusters. They include:

- Off-centre nozzles
- Accutrol nozzles
- Radiarc spray systems
- Controlled droplet application equipment

Off-centre nozzles produce a wide flat spray. The spray is off to the side of the nozzle. The spray is fairly even along its width. Off-centre nozzles are often mounted on the sides of trucks or short booms. They are used for spraying along roadsides, ditches, pastures, and places with many obstacles (e.g., brush and fences). These nozzles cover up to 10 metres, depending on nozzle size, pressure and wind.

Full (Solid) and Hollow Cone Nozzles

Figure 9-4: Solid and hollow core nozzles.

Full and hollow cone nozzles are used to apply fungicides and insecticides. They produce fine spray droplets for complete coverage. These nozzles are best suited for directed sprays where even application is not a must. They can be used over a wide range of nozzle pressures (200 to 2000 kPa).

Nozzle Pressure

Lower pressures tend to produce larger droplets. This reduces drift. For standard flat fan nozzles, pressures above 350 kPa (50 psi) produce fine droplets. Droplet size information (spray quality) can be obtained from the nozzle manufacturer.

Herbicides are often applied between 150-275 kPa (20- 40 psi). This keeps drift at a low level. Insecticides and fungicides are applied at higher pressures, between 300-2,000 kPa, (40-300psi). This gives a finer spray and better coverage. Different nozzle arrangements require different pressures.

Spray pressure also affects nozzle flow rate and spray pattern. Pressure should only be used to achieve small changes in flow rate. Pressure must be increased four times to double the flow rate. Low pressures create narrow fan angles. These can cause uneven patterns.

Spray Droplet Size

A nozzle can produce a range of droplet sizes. The number of fine droplets increases with spray pressure. Fine droplets also increase as the size of the nozzle orifice is decreased.

Nozzles are classified using an International scheme based on droplet size. Droplet diameter is measured in units called microns (1 micron equals 1/1000 mm). Volume Median Diameter (VMD) is a measure of the mean droplet size. For a given VMD, half of the spray volume is comprised of droplets that are smaller than this number. The other half of the spray volume is made up of droplets that are larger than this number.

In product catalogues, nozzle manufacturers often report nozzle spray quality over a range of pressures and flow rates.

Newer nozzles follow an International Standards Organization (ISO) standard colour coding system. This system identifies nozzle output in US gallons per minute at 40 psi

Table 9-1: International Standards Organization (ISO) standard colour coding system.

Colour Code	*Nozzle Output*
Orange	0.1 gal/min
Green	0.15 gal/min
Yellow	0.2 gal/min
Turquoise	0.25 gal/min
Blue	0.3 gal/min
Red	0.4 gal/min
Brown	0.5 gal/min
Gray	0.6 gal/min
White	0.8 gal/min

Table 9-2: International spray nozzle classification scheme

Classification	*Volume Median Diameter (VMD)*
VF (very fine)	less than 100 microns
F (fine)	100-175 microns
M (medium)	175-250 microns
C (coarse)	250-375 microns
VC (very coarse)	375-450 microns
XC (extremely coarse)	greater than 450 microns

Nozzle Materials

The rate of nozzle wear depends on the nozzle material, pesticide formulation, operating pressure, nozzle size, amount of use, and time used.

Nozzles made of harder material last longer. These are more costly to buy. Brass is one of the softest nozzle materials. Ceramic is one of the hardest nozzle materials. Other materials (e.g., stainless steel and plastics) fall between the two. Plastic and stainless steel have similar wear rates. Nozzle-wear increases with:

- More abrasive formulations
- Higher operating pressures
- Smaller nozzle sizes
- Longer use

Nozzle Replacement

The nozzle output and spray pattern changes with wear. This reduces application uniformity. To find the amount of wear, compare a worn nozzle's output to manufacturer specifications. Make sure that nozzle output is even across the boom. Replace nozzles that differ by more than 5% from the mean output of the other nozzles. Replace nozzles if mean output exceeds manufacturer specified output by more than 10%.

Clean Water Tanks

All motorized sprayers should have a clean water tank. This is a source of clean water for emergencies. A clean water tank supports routine tasks such as nozzle and hand cleaning.

Additional Components

Added components can be used to enhance the sprayer operation. Exposure is reduced and convenience increased through:

- Electronic controls
- Hydraulic or electric booms
- Induction systems
- Injection systems
- Enclosed cabs

Air-assistance, air blast, electrostatic, and spray hood systems can improve sprayer performance and reduce drift.

Items such as spray monitors and controllers can improve application. They supply information that can be used to maintain a constant application rate.

Drift control agents may change fluid viscosity. This affects distribution patterns, spray monitors, and controllers.

In Review

Parts of a sprayer include the spray tank, pump, agitator, strainers, control, and nozzles. These work to transfer liquid pesticides to the pest. Knowing how they work will help:

- **Promote effective use**
- **Ensure personal safety**
- **Project a professional image**
- **Protect bystanders**
- **Protect the environment**

Calibration

Calibration determines the amount of pesticide applied through a sprayer nozzle, duster, or granular applicator to a given area. This ensures the proper amount is applied to the target area or pest. Application equipment must be correctly calibrated. The following section details factors that need to be kept in mind to calibrate a number of equipment types.

Sprayer Calibration

A calibration process should:

- Ensure the sprayer and its parts are working.
- Ensure the sprayer is able to apply spray mixture evenly.
- Ensure a nozzle pressure to produce a droplet size that promotes good coverage and limits drift.
- Determine the equipment application rate. This rate must meet the label requirements.
- Determine the amount of pesticide to add to the spray tank.

Sprayers should be calibrated:

- When the sprayer is new
- At the start of each season
- When travel speed, nozzle spacing, or nozzles are changed
- When sprayer output changes
- When the sprayer is modified
- When parts are replaced

To calibrate equipment:

1. Set up the sprayer.
2. Measure equipment application rate.

3. Correct the equipment application rate and volume if needed.

4. Figure out the amount of formulated pesticide to add to the spray tank (see Pesticide Use Calculations).

Sprayers can be calibrated using the above steps. There are also some differences in spray equipment.

- Boomless nozzles, airblast sprayers, and hand-operated sprayers require a reading of total sprayer volume, spray width, and effective treatment width. Nozzle spacing and average nozzle output cannot be used.

- Directed sprays and banding equipment for row crops require knowledge of the total treated width per nozzle and the number of nozzles on the boom. The total output of the sprayer must also be known. Nozzle spacing and average nozzle output cannot be used.

- Some tree-fruit growers use a modified calibration process based on tree row volume. Volume of tree foliage is used to determine the amount of pesticide to apply. This is based on row volume.

- Air blast sprayers should have the liquid spray mixture and air delivery systems calibrated.

- Most broadcast sprayers are made with regularly spaced overlapping nozzles on horizontal booms. These provide an even application. For these sprayers, look at either:

    - Total boom output and total spray width

    - Average nozzle output and total spray width

    - Average nozzle output and nozzle spacing

Sprayer Setup

Sprayer setup involves finding the required equipment application rate. If needed, changes should be made to deliver this rate. Check to confirm that the sprayer is working properly.

Determine the Required Sprayer Output

The required sprayer output is found on the pesticide label. This is the amount of spray mixture applied per unit area. Sprayer output depends on:

- The crop
- Stage of growth
- The pest
- The pesticide
- Weather
- Soil conditions
- Method of application

Adjusting Sprayer Output

Once you have identified the sprayer output from the pesticide label calibrate the sprayer to deliver this amount. Sprayer output depends on:

- Spray width (or nozzle spacing)
- Total nozzle output (or average nozzle output)
- Travel speed

For broadcast spraying, with evenly spaced nozzles on a horizontal boom, average nozzle output and nozzle spacing can be used. Otherwise, spray width and total nozzle output are used.

FACTOR # 1 - SPRAY WIDTH OR NOZZLE SPACING:

When broadcast spraying with a horizontal boom:

Swath width of the sprayer = the # of nozzles X nozzle spacing

For band spraying with even flat fan nozzles:

Total swath width = spray width of each nozzle X the # of nozzles

When calculating sprayer output, the rate is for the treated area only. When using a single nozzle (e.g. hand sprayer), spray width is the width of spray on each pass.

For air blast or vertical boom sprayers:

Spray width = row width X the number of rows sprayed

Spray width should equal the distance between sprayer passes measured centre to centre. Nozzle arrangement and sprayer movement affects application uniformity. Some pesticide labels give nozzle guidelines.

FACTOR #2 - TOTAL AND AVERAGE NOZZLE OUTPUT:

Nozzle output is the volume of spray delivered by a nozzle in a given time period. Nozzle output is often rated in litres (L) or gallons per minute (gpm). To measure nozzle output, run the sprayer with water at the chosen pressure for a given time (e.g., 30 seconds). Collect the spray from each nozzle in a measuring cup. Divide total output of all of the nozzles by the number of nozzles. This gives average nozzle output.

Nozzle output depends on nozzle size and pressure. Increasing nozzle size and/or operating pressure will increase nozzle output. Nozzle type, size, and pressure affect droplet size. This affects spray coverage and drift.

Manufacturers give nozzle outputs in metric or U.S. units. Nozzle catalogues seldom use Imperial units. Be sure which units are being used. Manufacturers often list nozzle output over a range of acceptable operating pressures.

FACTOR #3 - TRAVEL SPEED:

Travel speed of the sprayer affects the calibrated sprayer output. For a given nozzle output, increasing travel speed decreases calibrated equipment application rate. Travel speeds for pull type boom sprayers often range from 8 to 13 km/h (5-8 mph). For self-propelled sprayers, travel speeds range from 15 to 30 km/h (10-20 mph).

Increasing travel speed decreases the calibrated equipment application rate or calibrated sprayer output (1:1 ratio).

Excess travel speeds cause boom movement. This causes uneven application. Choose a travel speed that minimizes boom movement. Travel speed is also an issue for air blast sprayers, especially when spraying large trees. Slow speeds are needed to provide good coverage. Going up and down hills changes speed. This changes sprayer output.

For hand held equipment, measure travel speed in the area where you plan to spray. Walk with the sprayer half full of water at a steady pace. Repeat in the opposite direction. Average the results. Walking speed varies with the applicator.

Example: Calculating Travel Speed

Travel Speed = test distance X constant ÷ time
Metric Units: km/h = metres X 3.6 ÷ seconds
Imperial Units: mph = feet X 0.68 ÷ seconds

Example:

A 60-metre test distance took 27 seconds to complete. The second run also took 27 seconds. The total time was 54 seconds. Total distance was 120 metres (60 X 2).

$$\text{Travel Speed (km/h)} \ \frac{120\text{m} \times 3.6}{54 \text{ sec}} = 8 \text{ km/h}$$

The travel speed required for nozzles can be calculated. Required sprayer output, nozzle output, and spray width must be known. Use average (not total) nozzle output.

Travel speed = required sprayer output x average nozzle output X spray width (or nozzle spacing for broadcast boom) ÷ constant.

<u>Values of constants:</u>

Metric: km/h = (L/ha) X (L/min) X cm ÷ 60,000.

Checking the Sprayer Operation

The last part of sprayer set-up is to make sure that the sprayer is working properly. It must apply the pesticide evenly. Uneven application leaves areas with too much or too little treatment. This can cause crop/plant damage. It can reduce pesticide effectiveness.

Non-uniform application can occur from variations across the width of the boom or local variations within the application area.

Variations in application across the width of the boom are caused by:

- Variations in nozzle output caused by mismatched nozzles
- Worn or plugged nozzles
- Changes in pressure across the width of the boom
- Poor alignment of flat fan nozzles
- Variations in nozzle spacing
- Improper boom height

Variations over the application area can be caused by:

- Changes in sprayer output caused by changing travel speed or pressure
- Too much boom movement
- Skips or a large overlap between passes of the sprayer
- Poor mixing or agitation of the pesticide
- A malfunctioning spray monitor

A number of checks should be performed during calibration. This ensures even application. Before starting the sprayer:

- Check all strainers and screens. This includes filler, suction and nozzle strainers. Check mesh size, holes, and cleanliness.

- Check all nozzles for correct type, size, spacing, and alignment on the boom.

- Check the boom for height above spray target. Ensure that height is level across the boom.

- Check the condition of the pressure gauge and pulsation damper air pressure.

Fill the sprayer with water. With the sprayer running, check the following:

- Set engine throttle at proper rpm to attain correct travel speed
- Flush lines with nozzles removed (if required)
- Check for leaks. Make sure that valves, agitation, and bypass flow are working
- Clean nozzles (and nozzle strainers) with distorted patterns. Discard damaged nozzles
- Adjust the pressure regulator. Check the pressure gauge. Measure pressure drop using a second pressure gauge. Use a nozzle adapter to connect it to the boom. Boom pressure should be uniform. This allows uniform nozzle output.
- Check for wear to nozzle openings. Measure the output of each nozzle.
- Calculate average nozzle output. Replace nozzles with outputs that are 5% greater or less than the average. Replace all nozzles when average output is more than 10% of a new nozzle.
- Check that nozzles and boom are arranged to provide even target coverage.
- Find the best swath width of the sprayer.
- Check air delivery systems of air assist and air blast sprayers. Ensure uniform air output and velocity.

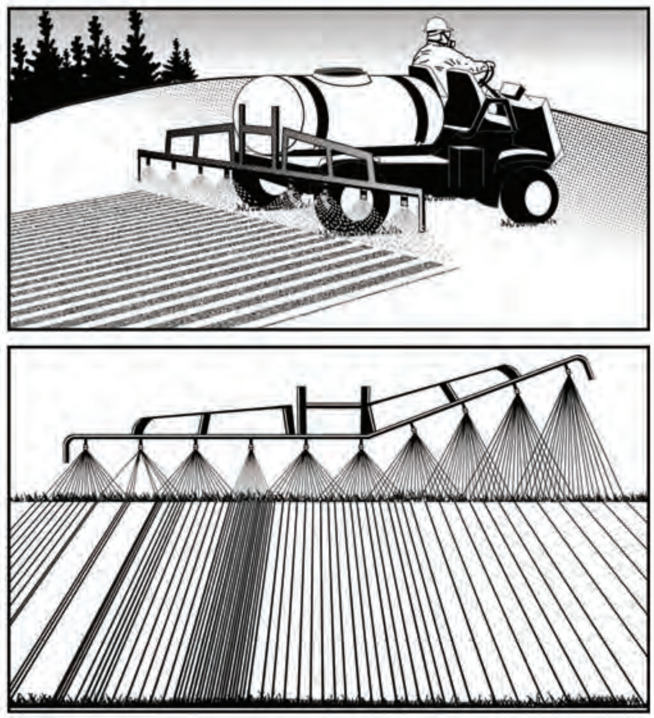


Figure 9-5: Improper boom height and clogged or worn nozzles can result in uneven application of pesticide and poor control of the pest.

Measuring Sprayer Output

Sprayer output is the spray mixture (pesticide and carrier) applied to a unit area (e.g., hectare, acre or meter of row). Sprayer output must meet label requirements. This allows the applicator to figure out the correct amount of pesticide to add to the tank.

A sprayer output may be given on the label. Sprayer outputs for broadcast treatments may be expressed as:

- An amount of spray mixture or product per hectare
- A range (e.g., 100 to 300 L/ha)
- Band treatments in amount per length of row (e.g., mL/m)
- Individual trees (L/plant)
- Spray to wet or runoff

Sprayer output can be measured by two methods: test area method and timed output method.

- The test area method uses fewer calculations. It may take longer to perform. When an entire acre or hectare is used, the measured discharge of water is the sprayer output per acre or hectare. No further calculation is required. The most common problem with test area method is measuring the amount of spray water discharged. The test area may be too small. The area may not be covered with enough passes. The amount of water discharged will be too small to measure. The tractor and sprayer tank should be parked in the exact same location. Water must settle in the tank after stopping, before measuring tank level again.

- The timed output method avoids the problems. Airblast sprayers or vertical booms can be used to spray row crops (e.g., raspberries). Total nozzle output and swath width of the sprayer are used to calculate the sprayer output. For broadcast sprayers with evenly spaced nozzles, the average nozzle output can be substituted for total nozzle output. Nozzle spacing can be used as the spray width. Nozzle spacing equals the spray width for one nozzle.

Using the Test Area Method

- Mark out a test strip.

- Fill the tank about half full with water. Start the sprayer nozzles and agitation. Adjust the pressure regulator to the desired pressure. Use the same engine rpm for the desired travel speed. Record the volume of water in the tank before the test. Mark the location where the sprayer is parked. This will allow you to return to the same position and measure the water sprayed. Level ground is best.

- Choose the tractor gear that will give the desired travel speed.

- Drive towards the first stake at the correct speed. Open the boom valve as you pass it.

- Check sprayer pressure again. Close the boom valve as you pass the second stake.

- Repeat until at least 10% of a full tank is sprayed. Record the number of runs.
- Return to the starting location. Measure the volume of water sprayed.
- Calculate the test area.
- Calculate the sprayer output.

Example: Test Area Method

Test Area = strip length X spray width X number of runs

Example: You test a hand-operated sprayer on a 10 m strip that is 2.5 metres wide. If you spray the strip twice, what is the area?

Test Area = Strip length X spray width X number of runs
= 10 m X 2.5 m X 2 runs
= 50 m^2

Metric Units: m^2 = m X m X number of runs
Imperial Units: ft^2 = ft X ft X number of runs

Sprayer Output = volume of water sprayed X constant ÷ test area

Example: A sprayer uses 15 L of water in a test area of 100 m2. What is the sprayer output per hectare?

Sprayer Output = volume of water sprayed X constant ÷ test area
= 15 L X 10000 ÷100m^2
= 1500 L/ha

<u>Values of constants:</u>

Metric Units: L / ha = L/m^2 X 10,000
Per Acre Units: L/acre = L / ft^2 X 43,560
American Units: GPA = gal/ft^2 X 43,560

Using the Timed Output Method

Fill the sprayer tank half full of water (see sprayer set-up).

Measure the travel speed of equipment in field conditions.

Measure total nozzle output (L/min) by spraying for a set time (e.g., 10 min) OR use the total nozzle output from measuring individual nozzle uniformity (see sprayer set-up).

Calculate the sprayer output for a single nozzle sprayer.

Example: Timed Output Method – Single Nozzle Sprayer

Sprayer output = total nozzle output X constant ÷ (speed X spray width)

Example: You calculate total nozzle output to be 2 litres per minute. Forward speed is 3 km/h. Swath width is 100 cm.

Sprayer Output = (L/ha) $= \frac{2 \text{ L/min} \times 60000}{3 \text{ km/h} \times 100\text{cm}}$

= 400 L/ha

<u>Values of Constants:</u>

Metric Units: L/ha = (L/min) / (km/h)/ cm X 60,000
Per Acre Units: L/acre = (L/min) / mph / inches X 5,940
American Units: GPA = gpm / mph / inches X 5,940

For broadcast sprayers, average nozzle output and nozzle spacing can be used instead of total nozzle output and spray width.

Calculate the sprayer output for a boom sprayer.

Example: Timed Output Method – Boom Sprayer

Sprayer output = average nozzle output X constant ÷ (speed X nozzle spacing)

Example: You calculate average nozzle output to be 2.5 litres per minute. Forward speed is 6 km/h. Nozzle spacing is 50 cm.

Sprayer Output = (L/ha)

$$= \frac{2.5 \text{ L/min} \times 60000}{6 \text{ km/h} \times 50\text{cm}}$$

$$= 500 \text{ L/ha}$$

Values of Constants:

Metric Units: L/ha = (L/min) / (km/h)/ cm X 60,000
Per Acre Units: L/acre = (L/min) / mph / inches X 5,940
American Units: GPA = gpm / mph / inches X 5,940

Adjusting Sprayer Output

If the measured sprayer output is different than what is required, it can be adjusted in one of three ways:

1. **Nozzle size** should be changed if large changes in sprayer output are needed. If needed, get help from the nozzle supplier or application equipment expert. Nozzle catalogues are available. These list nozzle outputs in litres per minute (L/min). Desired output of new nozzles can be calculated. The required sprayer output and travel speed must

2. **Forward speed** can be changed to adjust the sprayer output. Slower speeds increase the rate. Faster speeds reduce the rate. Traveling fast can cause the sprayer boom to bounce. This may prevent proper target coverage.

Calculate required speed with the following formula:

Example: Adjusting Forward Speed

Required speed = present speed X present sprayer output ÷ desired sprayer output

Example: You have just calibrated a sprayer. You calculate the present speed to be 8 km/h. Sprayer output is 100 L/ha. The pesticide label indicates that you must apply the pesticide in 120 L/ha of water. Calculate a new required speed that will give you a sprayer output of 120 L/ha.

$$\text{New required speed} = \frac{\text{present speed X present sprayer output}}{\text{Desired sprayer output}}$$

$$\text{New required speed} = \frac{\text{8 km/h X 100 L/ha}}{\text{120 L/ha}}$$

$$= \text{6.7 km/h}$$

Use this speed to see if the required label recommendations are met in the next example.

Calculate a new sprayer output if another tractor/truck gear and speed is chosen (rpm may be fixed because of the pump):

Example: Adjusting Sprayer Output

New sprayer output = present speed X present sprayer output ÷ new speed

Example: You calculate the present speed to be 8 km/h. Present application rate is 100 L/ha. The speed of your tractor slows to 6.7 km/h. Does the new reduced speed meet the label recommendations?

$$\text{New sprayer output} = \frac{\text{present speed X present sprayer output}}{\text{new speed}}$$

$$= \frac{8\text{ km/h X }100\text{L/ha}}{6.7\text{ km/h}}$$

$$= 120\text{ L/ha}$$

Yes, this meets the required sprayer output on the label.

3. **Spray pressure** should be set for the proper droplet size. Changing pressure is only advised for small changes in delivery rates for most nozzle types. Droplet size changes can cause drift or runoff. This is often not a good way to adjust application rate.

Pressure must be increased by four times to double the delivery.

Pesticide Use Calculations

Large Area Calculations

Pesticide-use calculations are required to determine the:

- Size of the treatment area
- Correct amount of pesticide required for the treatment area
- Amount of pesticide to add to the spray tank
- Area covered by the spray tank
- Total number of tanks required
- Volume of spray mix required for the final load
- Amount of pesticide required for the final load

These calculations are based on the pesticide rate chosen by the applicator from the label.

Before applying a pesticide, perform the calculations on the following pages:

1. **Determine the size of the treatment area.**

It can be obtained by measuring or from other sources (e.g., property maps or deeds). Any area that is not to be treated should be subtracted from the total area.

Example: Determining the Size of the Treatment Area

Area of a four-sided shape = length X width.

Example: You measure a treatment area as being 50 m by 150 m. What is the total area?

$$\text{Hectares} = \frac{\text{Length (m)} \times \text{Width (m)}}{10{,}000\ m^2/\text{ha}}$$

$$= \frac{150\ m \times 50\ m}{10{,}000\ m^2/\text{ha}}$$

$$= 0.75\ \text{ha}$$

Values of Constants:

Metric: Hectares = Length (m) X Width (m) ÷ 10000 m^2/ha.
Imperial: Acres = Length (ft) X Width (ft) ÷ 43560 ft^2/acre.

2. Determine the total amount of pesticide required. Use the following calculations:

Litres = Hectares X litres / hectare

Litres = Acres X litres / acre

Litres = square metres X litres / 100 m^2

Example: Determining the Total Amount of Pesticide Required

You need to treat an area of 0.75 ha. The pesticide application rate on the label is 2.0 L/ha.

The total pesticide required = treatment area x pesticide application rate

Example: The label rate is 2.0 L/ha. What is the total amount of pesticide required?

Litres of pesticide = Hectares X Litres / hectare

= 0.75 ha X 2.0 L/ ha

= 1.5 L

3. Determine the area covered by each tank. Use the following calculations:

Hectares/ tank = litres ÷ litres/hectare

Acres/tank = lites ÷ litres/acre

Acres/tank = gallons ÷ gallons/acre

Example: Determine the Area Covered by Each Tank

Area covered by tank = tank size ÷ sprayer output

Example: Your tank holds 500 L. The pesticide label advises a sprayer output of 1000 L/ha. What is the area that will be covered by a full tank?

Area covered by tank = litres ÷ litres/hectare

$$= \frac{500\ \text{L}}{1000\ \text{L/ha}}$$

$$= 0.5\ \text{Ha}$$

4. Pesticide to add to the full spray tank.

a. When pesticide rate is expressed as a rate per area:

Litres = Litres/hectare X hectares/tank

Litres = Litres/acre X acres/tank

Litres = litres/100 m^2 X 100 m^2/tank

Example: Determining the Amount of Pesticide to Add when Label Rate is Given Per Unit Area

Pesticide per tank = pesticide application rate x area covered per tank

Example: The pesticide label calls for an application rate of 2.0 L/ha. Your tank covers 0.5 ha. What is the amount of pesticide required for a full tank?

Litres = Litres/hectare X hectares/tank

= 2.0 L/ha X 0.5 ha

= 1 L

b. When the pesticide application rate is expressed as a dilution factor:

Example: Determining the Amount of Pesticide to Add when Label Rate is given as a Dilution Factor

Pesticide per tank = tank size X dilution factor

Example: The pesticide label calls for a pesticide application rate of 2.5L/100L. Your tank holds 250 L. What is the amount of pesticide required for a full tank?

Litres = Litres X Litre/Litres

= 250 L X 2.5 L/100 L

= 6.25 L

5. **Determine the total number of tanks needed. Use the following calculations:**

Tanks = hectares ÷ hectares/tank

Tanks = acres ÷ acres/tank

Total number of tanks can include a partial tank

Example: Determining the Total Number of Tanks Needed

Total number of tanks = treatment area ÷ area covered per tank

Example: The area to be treated is 0.75 ha. Your tank covers 0.5 ha. How many tanks do you need to fill to complete the treatment?

Tanks = hectares ÷ hectares/tank

= .75 ha ÷ 0.5 ha/tank

= 1.5 tanks

6. **Determine the hectares left to be sprayed. Use the following calculations:**

Example: Determining the Hectares Left to be Sprayed

Area (hectares) left to be sprayed = total area (hectares) - area (hectares) already sprayed

Example: You complete spraying 0.5 ha before lunch. The total area is 0.75 ha. What is the area left to be sprayed after lunch?

Area (ha.) left to be sprayed = total area (ha) - area (ha) already sprayed

= 0.75 ha – 0.5 ha

= 0.25 ha

7. **Determine the volume of spray mixture needed for a partial tank. Use the following calculations:**

Litres = hectares X litres/hectare.

Litres = acres X acres/hectare.

Gallons = acres X gallons/acre.

Example: Determine the Volume of Spray Mixture Needed for a Partial Tank

Volume of spray mixture (pesticide + water) for a partial tank = area left to be sprayed X sprayer output

Example: The sprayer output is 1000 L/ha/ha. The area left to be sprayed is 0.25 ha. What is the required volume of spray mixture in the tank?

Litres = hectares X litres/hectare

= 0.25 ha X 1000 L/ha

= 250 L

8. **Determine the volume of pesticide needed for a partial tank. Use the following calculations:**

Pesticide for a partial tank = treatment area left X pesticide application rate

Litres = Hectares X Litres/hectare

Litres = Acres X Litres/acre

Example: Determine the Pesticide Needed for a Partial Tank

Pesticide for a partial tank = area left to be sprayed X pesticide application rate

Example: The pesticide application rate is 2.0 L/ha. The area left to be sprayed is 0.25 ha. What is the required volume of spray mixture in the tank?

Litres = hectares X litres/hectare

= 0.25 ha X 2.0 L/ha

= 0.5 L

In Review

A full tank has 1 L of pesticide in 500 Litres (1 ÷ 500 = 0.002)

A part tank has 0.5 L of pesticide in 250 Litres (0.5 ÷ 250 = 0.002)

The ratio of 0.002 is the same

Small Area Ground Beds Calculations

For potted plants, a 1000 litre solution should cover roughly 5,000 m^2 of total greenhouse area. Ensure that proper volume of spray mix is being delivered to the treatment area.

Area (m^2) = length (m) X width (m)

Hectares= length (m) X width (m) ÷ 10,000m^2

Example: Calculating a Small Area

You measure a small treatment area as 50 m by 150 m. What is the total area?

Hectares	**=**	**length (m) X width (m) ÷ 10,000 m^2/ha**
	=	**150 m X 50 m ÷ 10,000 m^2 /ha**
	=	**0.75 ha**

In Review:

A sprayer can be set up by measuring and changing sprayer application rates. Pesticide use calculations must be made. All of these methods must be used to be sure that a correct application will be made.

Environmental Considerations for Using Boom Sprayers

Before any application, check environmental conditions at the application site. Be mindful of sensitive non-target areas nearby. Spray and vapour drift must be minimized. Water quality can affect pesticide performance or application equipment. The following section deals with environmental factors that impact pesticide application.

Buffer Zones

Pesticide labels may include statements on buffer zone distances from sensitive areas. A buffer zone is the distance from the downwind edge of direct pesticide application to the nearest upwind edge of the sensitive area. Buffer zones protect sensitive non-target areas from pesticide damage. In some cases, buffer zone width may depend on weather and application methods.

Spray and Vapour Drift

Before any application, make note of weather conditions at the site. This indicates spray drift potential. Consider:

- Air and ground temperature
- Relative humidity
- Wind speed and direction
- Forecast weather conditions

Consider factors that may put areas around the application site at risk to effects of drift. Factors include nearness to:

- Surface water
- Sensitive plants
- People or animals
- Other sensitive areas

Reduce spray drift by only spraying in favorable weather. High temperatures and low humidity combine to increase evaporation. This results in small droplets that can drift off target. Higher wind speeds can cause drift in the direction of the wind. Maximum wind speeds during application may be given on the label or by provincial guidelines/laws. Wind speed indicators (anemometers) and pictorial comparisons can be used to judge wind speed. Applicators should use accurate hand-held anemometers to gauge wind speed and direction at the time of spraying. If spray drift occurs, stop the application. Do this, even if wind speeds are acceptable. Avoid variable wind conditions (e.g., gusting or windless conditions). Changing wind conditions may blow droplets onto non-target plants/organisms.

If spray drift is a concern, consider doing the following:

- Increase droplet size by lowering pressure.
- Use a low drift nozzle.
- Use a coarser spray quality (droplet size).
- Use a spray guard or shroud.
- Use equipment that reduces or eliminates drift (e.g., wick application equipment).
- Use drift control agents.
- Lower boom height or hold the spray gun closer to the target. Nozzles can be tilted forward to maintain boom height for proper overlap and even application. It should be noted that lowering the boom and using nozzles with wider spray patterns (finer droplets) may not reduce drift.

Minimize vapour drift by doing the following:

- Choose a less volatile pesticide (e.g., amine versus ester formulation).
- Apply pesticide under proper wind conditions. Windless conditions can cause vapours to remain in the air. These can damage non-target areas. A 2 km/h wind away from non-target areas generally reduces risk.
- Apply the pesticide under proper temperature and humidity. High temperatures and low humidity increase volatilization.

Temperature inversions occur when cooler air lies underneath warm air. Temperature inversions sometimes occur with the large high-pressure systems depicted on weather maps. These systems often combine temperature inversion conditions and low wind speeds. Temperature inversions can cause spray or vapour drift to stay concentrated. This increases risk from downwind movement. Pesticides should not be applied during temperature inversions. Wind directions can change during these times. Apply pesticides on sunny days with low wind speeds in a constant and predictable direction.

Increase Droplet Size

Insecticides and fungicides are often applied with smaller spray droplets than herbicides. Smaller droplet size improves coverage (number of drops per leaf). This allows the spray to pass through a dense canopy. Using large droplets to apply insecticides and fungicides may reduce effect. Insecticide and fungicide use may require a compromise between drift reduction and pesticide effect. Applicators can reduce spray drift by using larger droplet size. Droplet size gets larger as nozzle orifice size increases and pressure decreases.

A nozzle with a small orifice used at high pressure may have the same output as a larger nozzle used at a lower pressure. Risk of drift is much greater for a nozzle with small orifices. Increasing spray angle on nozzles decreases droplet size at the same pressure. Some nozzles are designed to provide larger droplets as well (e.g., low-drift, drift guard, and air induction). Changing nozzle types may increase droplet size for the same nozzle flow rate and pressure.

For standard nozzles, when a larger orifice is chosen and the same pressure used, there may be higher nozzle output. The applicator can increase travel speed to compensate for this or accept a higher equipment application rate. It may be possible to balance both of these factors. But, travel speed should not be excessive. Application rate must not exceed the maximum application rate stated on the label. For all nozzles, pressures should remain within the manufacturer's guidelines.

Drift Control

Wind Cone Spray Wands

Hand held spray wands can be shrouded with a windcone. This is mounted near the nozzle tip. The wind cone will reduce drift from wind gusts. It also promotes good target coverage. This reduces contact with non-target objects that are nearby (e.g., shrubs). Wind cone spray wands are safe for the applicator. They allow one to control the application target area. Manufacturers report that spray drift can be controlled in up to 20 km/hr winds.

Windfoil Spray Booms

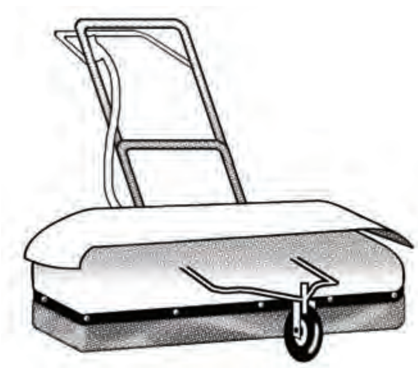


Figure 9-6: Spray boom equipped with Windfoil.

Boom-type spray wands can be enclosed in a shrouded canopy. This reduces spray drift by reducing wind contact. Windfoil spray booms have flotation wheels. A front swivel-type wheel can be added for more stability. An airfoil is a flat curved bar mounted on the top of the shroud. This gets rid of updrafts behind the windfoil during spray application. Manufacturers report windfoil spray booms to be effective in reducing drift for up to 30 km/hr.

Water Quality and Pesticide Effectiveness

Temperature, sediment, pH, and mineral ions in water mixed with pesticides may affect pesticide performance. High pH can break down some insecticides. It can also reduce solubility of some herbicides.

The rate of pesticide breakdown depends on:

- pH of water
- Amount of pesticide added to a given amount of water
- Water temperature
- The length of time a solution is left in the spray tank

Silt and organic matter in the water may cause:

- Early pump wear
- Plugged screens
- Reduced pesticide effect

If you suspect a problem with water quality, you should:

- Have the water tested
- Seek another water source
- Obtain advice on pesticide application

Refer to the pesticide label or provincial publications for guidelines.

In Review

Environmental conditions can play an important part in how well pesticides are applied. Attention must be paid to:

- **Buffer zones (to protect sensitive areas)**
- **Water quality (to ensure pesticide effect)**
- **Spray and vapour drift (to avoid the risk of off-target movement)**

Sprayer Maintenance

Liquid application equipment must be maintained to keep it running well. There are also a number of things that must be done when parking or storing a spray vehicle. These topics are discussed in the following section.

Routine Maintenance

Taking care of application equipment minimizes breakdowns. This increases service life, and reduces leaks and spills.

Rinse equipment at the end of each spraying day. Flush clean water through the pump, hoses, and nozzles. Check and clean all screens, strainers, and nozzles. Check the sprayer for wear. Replace worn or damaged parts. Major parts to check include the:

- Agitator
- Regulator
- Pressure gauge (check for accurate operation)
- Couplings and clamps (check for proper seals)
- Hose flex points (check for wear)

Wash the sprayer. Dispose of rinsate where residues will not cause environmental harm. Follow label directions and provincial laws.

Decontaminate the sprayer, when changing pesticide types (e.g., herbicides to insecticides). Steps vary according to the pesticides being used. Check the pesticide label or manufacturer's representative for details.

Temporary Storage of Spray Vehicles

Choose a site with care when parking spray vehicles:

- Do not park near sensitive plants. Herbicide vapours may pose a hazard. Spray solution may move off a vehicle deck during rainfall.

- Do not park where herbicides can drain into storm sewers.

- Do not park where vandalism can occur.
- Do not park in urban areas, particularly with a full spray tank.

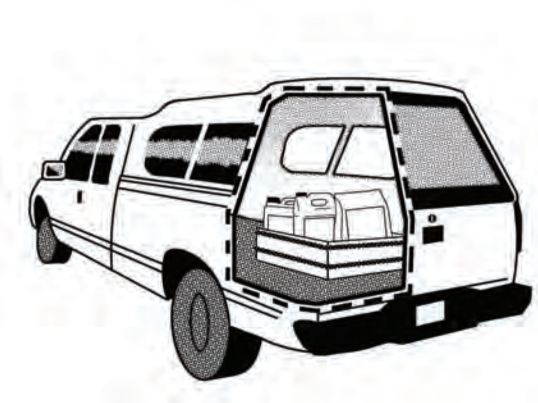


Figure 9-7: Secure pesticide containers in a locked area to prevent tampering or theft.

If you must park near sensitive vegetation or in urban areas, lock all valves. This prevents spray solution from escaping in the case of a break-in. Secure pesticide containers to prevent tampering or theft. Equipment should be checked daily for tampering (before application). Ensure that contaminated clothing is stored in a secure location away from clean clothing. All spills on decks must be properly cleaned.

Provincial law may not allow leaving pesticides, spray solutions, and loaded spray equipment unattended. Refer to provincial law and be aware of requirements in your province.

To prepare a sprayer for end of season storage:

1. Thoroughly clean the sprayer and drain it completely. Drain all components that can retain water. Follow the manufacturer's guidelines on adding antifreeze solution.
2. Check the sprayer for worn parts. List all parts that need replacement. Order parts well before the next spraying season.
3. Remove the pump. Follow the manufacturer's guidelines for storage.
4. Seal openings to prevent entry of dirt, debris, insects, or rodents.

5. Store the sprayer where it cannot be damaged by other equipment, livestock, or weather.

6. Store polyethylene tanks under cover. This prevents breakdown by sunlight.

7. Keep galvanized steel tanks dry to prevent rusting.

In Review

Sprayers should be rinsed after each day's use. Many sprayer parts should be checked regularly for dirt and wear. Decontaminate equipment when one pesticide type is replaced by another. This avoids harmful residues or other damage. Spray vehicles must be parked to prevent tampering or accidental release. End of season storage requires complete drainage and protection from damage.

Granular Application Equipment

Pesticide granules must reach the target pest. To ensure that they do, you must choose proper equipment and understand its parts. The following section describes common landscape granular application equipment.

Components of Granular Application Equipment

Components of granular application equipment include:

- Storage hoppers
- Metering mechanisms
- Distribution systems

Storage Hopper

Storage hoppers hold granular pesticides. They come in a number of shapes, sizes, and materials. A hopper should:

- Be corrosion resistant
- Be strong
- Be shaped to promote granule flow
- Be easy to fill
- Have graduated markings
- Be easy to clean

Agitators can be installed in hoppers to prevent bridging (blockage) of granules. A granular pesticide may bridge because of:

- Pesticide characteristics (type, shape, and size of formulated granule)
- The shape of the hopper
- Air temperature and humidity

Coarse screens can be installed on hoppers. These prevent pieces of the pesticide bag or clumps of product from entering the hopper. This will prevent the drive mechanism from clogging.

Metering Mechanism

There are two main types of metering mechanisms used in granular pesticide application equipment:

Gravity flow metering mechanisms use openings that can be manually adjusted in size. These regulate flow of pesticide from the hopper. A hopper agitator is often used to promote a steady flow of granules to the opening.

Positive metering mechanisms use an auger or fluted-feed roll at the bottom of the hopper. This regulates the flow of granules from the hopper. A ground driven wheel often powers positive metering mechanisms. These are more accurate than gravity flow metering mechanisms.

Distribution System

Granular application equipment is classed by the kind of distribution system it has. Broadcast and banding are two common types of distribution systems.

Broadcast application equipment applies granules over the entire field surface. This equipment often uses:

- A very wide hopper with closely spaced gravity flow openings
- A single gravity flow opening with a mechanical spreader
- A pneumatic delivery system

Band application equipment applies granules in narrow bands. This often corresponds to crop rows. Untreated areas are left between the rows. Banding reduces pesticide use. Pesticides are only applied to areas requiring treatment.

Banding application equipment may use:

- Simple spreaders to spread granules across the desired band width on the soil surface
- Small drop tubes or soil openers to place granules under the soil surface near the seed in well-defined bands

In Review

Major parts of granular equipment include storage hoppers, metering mechanisms, and distribution systems. These work to bring granular pesticides to the target pest. Knowing how they work will make pesticide application more effective.

Calibration

Application Uniformity

The goal of equipment calibration is to achieve a uniform application of pesticide. Application uniformity affects pesticide performance. Uneven application leaves areas of over and under-application. This reduces pesticide effect.

Uneven application can result from:

- Changes in granule outputs
- Changes in travel speed
- Changes in discharge heights (when banding)
- Improper overlapping between passes

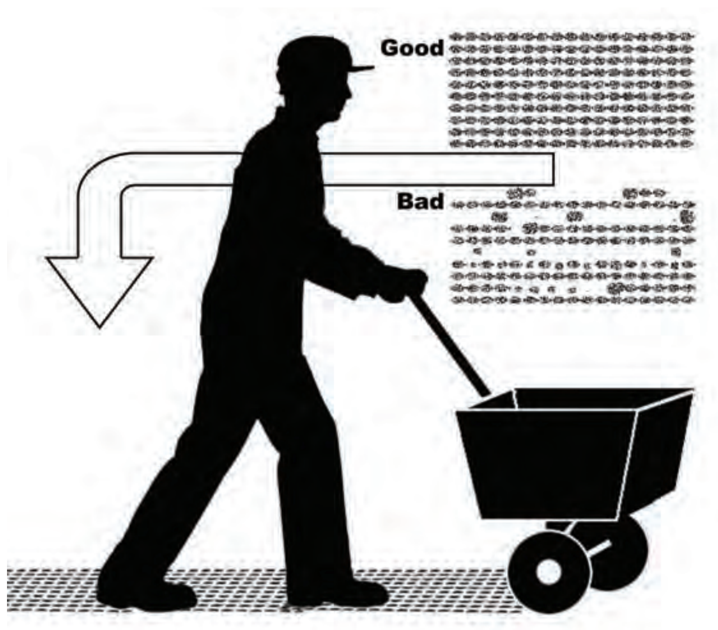


Figure 9-8: To obtain good control ensure granular application rate is uniform.

Equipment Application Rate

Equipment application rate is the weight of pesticide per unit area applied by granular application equipment.

The pesticide rate is the weight per unit area called for on the pesticide label.

Equipment application rate and pesticide rate are often expressed as:

- Broadcast treatment (kg/ha)
- Banding treatment (kg/ha or kg/m of row)

Equipment application rate depends on:

- Granule flow rate
- Travel speed
- Treatment width

GRANULE FLOW RATE

Granule flow rate is the rate at which granules flow from the hopper (weight per time). Granular flow rate depends on:

- The size of the opening
- Granule size and density
- Formulated pesticide characteristics
- Air temperature and humidity

An increase in humidity may decrease granule flow rate.

Larger or less dense granules flow more slowly through the same sized opening (when compared with smaller or denser granules).

Bouncing in rough fields disrupts the steady flow of the granules. This reduces uniformity.

The metering mechanism can be adjusted to set the granule flow rate from the hopper. The correct setting is determined during calibration. Once set, metering mechanisms are not usually changed during application.

The flow rate of gravity flow mechanisms can be adjusted by changing the size of the opening. The rotational speed of the agitator can also affect flow rate.

The flow rate of positive metering mechanisms can be adjusted by changing the size of the opening. The rotational speed of the metering mechanism can also affect the flow rate.

Field conditions can affect flow rate from the hopper. Rough fields cause equipment to bounce. This disrupts steady flow of granules. Changing flow rates reduce uniformity. Sloping fields may also affect uniformity.

The granular flow rate of each discharge opening should be measured. This ensures even application across the total width of the equipment. Measurements should be taken in field conditions.

TRAVEL SPEED

Travel speed affects equipment application rate. Increasing travel speed decreases application rate for granular application equipment using gravity flow metering mechanisms.

If granular application equipment uses positive metering mechanisms, small changes in travel speed will not greatly alter equipment application rate when the metering mechanism is ground-driven.

Travel speed selected during calibration should be maintained during application, no matter what metering mechanism is used.

TREATMENT WIDTH

Treatment width is used to find the equipment application rate. This depends on the type of distribution system used.

For broadcast application equipment, treatment width equals the total width of granules applied in each pass.

For band application equipment, treatment width equals the total of all the individual bandwidths in one pass.

When granules are banded under the soil surface, the application equipment output is generally expressed as kg/m of row. Treatment width is not taken into account.

Granular Application Equipment Calibration

Granular application equipment should be calibrated:

- When application equipment is new
- At the start of each season
- When travel speed, metering mechanism, weather, or pesticides change
- When equipment application rate changes

Calibration Process

1. Determine a proper travel speed. Take field conditions into account. Select a gear/rpm setting that provides desired travel speed. Record this information. Maintain this speed throughout calibration and application.

2. Select a test site. This may be the field where the application occurs. It may be an area with similar soil and terrain conditions. Mark a test distance at least 50 meters in length.

3. Fill the hoppers roughly half full for average weight conditions.

4. Consult the operator's manual for the recommended setting of the metering mechanism. Note: The flow rate called for in the manual may need to be altered based on the type of pesticide, weather, and field conditions. Always calibrate to ensure that granule flow rate is correct.

5. Attach bags or other containers under each opening. This collects granules during calibration. Try to use a blank carrier to avoid exposure. Special collection containers may be available from the pesticide maker. These are calibrated with a scale showing weight. For granular equipment with a pneumatic delivery system, use porous mesh bags (e.g., nylon) OR shut off airflow, and catch granules at the metering mechanism.

6. Run the application equipment over the test distance at the correct gear/rpm. To reduce error, acceleration and deceleration distances should be kept short. Granule flow cannot be controlled from the operator's seat.

7. Remove the bags/containers. Weigh and record the contents in each. Enough material must be collected during the test to allow for accurate weighing on available scales. Do not use a scale that is used for food.

8. Repeat the test in both directions. Average the results.

9. Calculate equipment output. Compare this to pesticide rates on the label. Assess flow rate uniformity by comparing the individual values to the average value. Adjust and recalibrate if necessary.

Be sure that granules are correctly placed during calibration. To adjust band width, spreaders or tubes can be raised or lowered.

Calculate:

- The calibration area
- Total amount collected
- Treatment area
- Total amount of pesticide product required

Calculations

1. **Determine treatment area. Use the following calculations:**

Kg = Hectares X Kg/hectare

Kg = Acres X Kg/acre

Example: Determining the Amount of Pesticide Required

Treatment area = length X width ÷ 10000

Example: An area to be treated is 50 m by 150 m. Label application rate is 2 kg/ha. What is the amount of pesticide required?

Treatment area	**= Length (m) X Width (m) ÷ 10,000 m^2/ ha.**
	= 150 m X 50 m ÷ 10000 m^2/ha
	= 0.75 ha
Kg of pesticide	**= Hectares X Kg/hectare**
	= 0.75 ha X 2 kg/ha
	= 1.5 kg

2. **Determine the total weight of granules discharged. Use the following calculations:**

Example: Determining the Total Weight of Granules Discharged

Total granules discharged = total weight of individual openings discharged over the test area.

Example: The weights of granules for each opening in a spreader were as follows: 2.2 kg, 2.1 kg, 3.0 kg, 2.7 kg and 2.5 kg. What is the total weight of granules discharged?

Total granules discharged

= 2.2 kg + 2.1 kg + 3.0 kg + 2.7 kg + 2.5 kg

= 12.5 kg

3. Determine the amount of pesticide used per unit area.

a. For Broadcast equipment, use the following calculations:

Kg = Hectares X Kg/hectare

Kg = Acres X Kg /acre

Example: Determine the Amount of Pesticide Used Per Unit Area for Broadcast Equipment

Broadcast (kg/ha): Equipment Application Rate = total granules discharged X treatment area

Example: A granular spreader applies 100 kg/ha. You need to treat an area of 6.2 ha. How much granular pesticide do you require to treat the area?

Kg = Kg/hectare X Hectares

= 100 kg/ha X 6.2 ha

= 620 kg

b. For banding equipment, use the following calculations:

Example: Determine the Amount of Pesticide Used Per Unit Area for Broadcast Equipment

Banding (kg/m): Equipment Application Rate = total granules discharged ÷ distance/band X number of bands

Example: A certain spreader has 3 bands. Each band has an output of 50 kg/1000m. What is the equipment application rate?

Banding (kg/m): Equipment Application Rate = total granules discharged/band X number of bands ÷ distance/band

Equipment Application Rate = 50 kg x 3 bands / 1000m

= 0.15 kg/m

4. **Determine the total amount of pesticide required. Use the following calculations:**

Example: Determining the Total Amount of Pesticide Required

Total pesticide required = treatment area X label pesticide rate

Example: The label pesticide rate is 12 kg/ha. The total area to be treated is 3 ha. What is the total pesticide required?

Total pesticide required = treatment area X label pesticide rate

= 3 ha X 12 kg/ha

= 36 kg

Environmental Considerations for Granular Application

Before any granular application, look at environmental conditions at the application site. Look for sensitive wildlife areas nearby. The following section details environmental factors that impact the application of pesticides.

Weather Conditions

Before any application, check the weather to assess the risk of problems. High winds may:

- Affect distribution of granules
- Decrease uniformity
- Change band width

A change in humidity can alter the flow rate of the granules. This can affect equipment application rate.

Wildlife

Granular insecticides should be mixed into the soil. This will reduce the risk to wildlife by reducing the chance of ingestion. Refer to the pesticide label for details.

Maintenance

Proper maintenance of granular application equipment keeps it in good running order. A number of things need to be done when equipment is prepared to be stored at the end of the season. These are discussed in the following section.

Taking care of application equipment reduces the chance of breakdowns. This increases service life. Never leave granules in the hoppers for long periods. They may absorb moisture and harden into lumps. Before using equipment, make sure that no moving parts have seized from corrosion. Granules are abrasive. This means that all moving parts of the equipment must be frequently greased or oiled. Too much lubrication can cause a build-up of granules, dust and dirt. This can increase wear and hinder equipment use.

Check tire pressure before use. Air pressure determines the effective size of the tire. This also determines equipment output for ground-driven equipment. Overinflated tires cause bouncing. This reduces uniformity. Check the delivery system. Make sure that granules have a clear path from the metering mechanism to the target.

To prepare equipment for storage:

1. Thoroughly clean it.
2. Lubricate all moving parts.
3. Follow the manufacturer's guidelines.
4. Check and replace worn parts.
5. Store it where it will not be damaged by other equipment, livestock, or weather.

In Review

The parts of granular equipment should be often checked for dirt and wear. Granules are abrasive and can harden and clump with time. Care is needed to ensure proper equipment operation. Regularly lubricate equipment and check tire pressure according to manufacturer's guidelines. Store equipment properly at the end of the season to avoid damage.

Summary

Pesticides are potentially dangerous chemicals that must be handled properly to ensure that pests are controlled, while damage to the environment is avoided. To make sure that the pesticide reaches the target pest with the least risk to humans, animals, and the environment, use proper:

- **Equipment**
- **Components of liquid and granular equipment**
- **Calibration of sprayers and granular spreaders**
- **Pesticide use calculations**
- **Equipment maintenance**
- **Environmental considerations**

Self-test Questions

Answers are located in Appendix A of this manual.

1. Name three types of spraying equipment often used in landscape and turf pest management.

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2. List the main parts of motorized boom sprayers.

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3. Flat fan nozzles are often used for which application types?

   a) Insecticide
   b) Herbicide
   c) Fungicide

4. What are four steps required to calibrate application equipment?

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5. What are three factors that affect required equipment application rate?

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6. List the weather factors to keep in mind when using pesticides.

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7. In addition to spraying only under proper weather conditions, how can you avoid spray drift?

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8. How is application equipment maintained?

9. Describe the main parts of a granular applicator.

10. What represents the final treatment width in band application equipment?

11. How is the impact of granular insecticides on wildlife reduced?

12. How is granular equipment prepared for storage?

Chapter

10

PROFESSIONALISM

Those who work in the turf care and landscape industry know that pesticides can be valuable tools in integrated pest management (IPM) programs. Landscape pesticides are often used in populated areas. For example, pesticide applications can be made for pests of trees found along streets or on green spaces that people use (e.g. lawns, golf courses, schools, and playgrounds). There is more risk of exposure and harm to humans than with applications in remote areas (e.g. farming and forestry). Some members of the public are strongly opposed to pesticide use in urban areas. The reasons for this can be varied and include medical, environmental and personal reasons. Others wish to see pesticides used to maintain turf and landscaped areas in safe, useable or attractive condition. This creates a challenge for landscape managers. Urban pesticide use often has a high profile and can create controversy. Pesticide applicators are often closely watched by the public and media. Applicators must work as professionals, balancing their IPM skills with client demands and public concerns.

Learning Objectives

Completing this chapter will help you to:

- **Know the importance of dealing with the public in matters related to pesticide use in the turf care and landscape industries.**
- **Know the importance of a professional image.**

Reducing Bystander Exposure

Turf and landscape pesticide applicators must prevent bystanders from being exposed to pesticides They must also obtain the results expected by their clients. The following sections deal with these issues.

Advice to the General Public

Landscape pesticide applications are carried out in residential and public areas. This increases the risk of exposure of the public. Pesticide applicators must be aware of nearby human activities. This allows them to reduce the risk of bystander exposure.

To reduce exposure to others:

- Notify the owners of nearby properties prior to application. This may be required in some provinces. Contact your provincial regulator for additional information.
- Post the area at all points of access during the application.
- Avoid applications in schoolyards when children are present.
- Apply pesticides in residential areas when there are few people around.
- Apply pesticides to commercial and public property during off-hours or times of reduced traffic.
- Where possible, restrict access to treated areas of public or commercial properties until the pesticide has dried.

Advice to Clients

Indirect pesticide exposure to humans and pets can be avoided by telling property owners when an application has taken place. Advise them to keep children and pets off treated areas until the pesticide has dried or the granules have dissolved.

Treatment sites should be posted for at least 24-48 hours after an application. Signs on all points of access should give the name of the pesticide used. A contact phone number, time and date of application, and target pests should be given. Consult your provincial regulator for details on posting. In some cases, municipalities may have additional posting requirements.

Precautions to Minimize Exposure

Before any pesticide application, remove or cover all outdoor items (e.g., patio furniture, children's toys, sandboxes, pet toys and dishes). This reduces the risk of indirect exposure.

Showing Competence

To allay public concerns, applicators should work with competence when using pesticides in and around populated areas. Competency is shown by:

- A positive personal appearance
- Good hygiene
- Technical knowledge
- A professional attitude

Practicing IPM shows competence. To practice IPM, an applicator needs to know the biology of the pest and be able to use a number of control methods to get the best results.

Along with provincial certification requirements, professional applicators should continue to build on their IPM skills and knowledge. New control methods, equipment, and products are always being developed. Applicators need to keep up to date with developments in pest management. This can be done by:

- Reading journals
- Going to seminars
- Taking part in information sharing sessions with local groups
- Joining provincial and national groups

Communicating effectively with clients also demonstrates professionalism. When dealing with clients:

- Find out their needs.
- Tell the client what the pest management program involves.
- Tell people living or working near the area before performing a treatment.
- Answer client questions. Provide sources of information.
- Inform clients when an application has taken place. Tell them what is involved.

Summary

Operating in a professional, competent manner will help reduce public concern and controversy over urban pesticide use. Pesticide applicators should:

- **Project a professional image**
- **Work in a professional manner**
- **Have a good attitude**
- **Have up-to-date knowledge of their profession**
- **Use an IPM approach**
- **Communicate effectively with clients and the public**

Self-Test Questions

Answers are located in Appendix A of this manual.

1. Knowing the biology of the pest and methods of control show competence when using landscape pesticides. **True or False?**

2. Posting the area at all points of access during the application reduces risk of bystander exposure to landscape and/or turf pesticides. List three (3) other ways.

   ____

   ____

   ____

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IPM Journal:

IPM Practitioner. Bio-Integral Resource Center, P.O. Box 7414, Berkeley, CA 94707 Tel: 510-524-2567 Fax: 510-524-1758 www.birc.org

Identification Guides:

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IPM Training and Consulting:

Wild WoodLabs Tel: 902-679-2818 Fax: 902-679-0637 Email: info@wildwoodlabs.com Web: http://www.wildwoodlabs.com

Nova Scotia Agricultural College, Centre for Continuing and Distance Education, PO Box 550, Truro, NS B2N 5E3 Tel: 902 893-6666 Fax: 902-895-5528. www.nsac.ns.ca/cde/coursedes.htm

APPENDIX A:

ANSWERS TO SELF-TEST QUESTIONS

ANSWERS TO SELF-TEST QUESTIONS

Chapter 1: General Information

1. Organophosphate and carbamate.
2. 2,4-D and MCPA.
3. Botanical pesticides. Pyrethrum is the most common.
4. Piperonyl butoxide enhances the effect of pyrethrum.
5. False. Pyrethrum, the most common of the natural pyrethroid group, is extracted from the flower heads of the chrysanthemum plant. Synthetic pyrethroids are man-made equivalents of natural pyrethrums.

Chapter 2: Human Health

1. False. Repeated exposure to small doses of organophosphate insecticides can be very dangerous.
2. True.
3. True.
4. False. Unlike organophosphate compounds, carbamates are quickly broken down in the body. Their effect on cholinesterase inhibition is brief.
5. Phenoxy herbicides.
6. Symptoms of acute poisoning may include nausea, vomiting, cough, and irritation to the lungs (may progress to bronchial pneumonia with fever and cough).

7. True.

8. This can cause a number of poisoning symptoms. This includes headache, fatigue, or dizziness in mild poisoning. Symptoms of severe poisoning include nausea, trembling, twitching, convulsions, respiratory failure, heart difficulties, and even death.

9. Each person has a different baseline value of cholinesterase. You must have a blood test before handling or using these pesticides. A pre-season blood test can give a person's normal (baseline) value of cholinesterase.

10. False. Herbicides in the phenoxy chemical family are not cholinesterase inhibitors.

Chapter 3: Pesticide Safety

1. Spray below shoulder height to reduce applicator and bystander exposure to drift.

2. Wear gloves and goggles.

3. True.

4. **a**. A respirator may only be required for some pesticides.

Chapter 4: Environment

1. Avoid:

   a. Contamination of fishponds and pools.

   b. Drift or leaching to nearby properties.

   c. Contamination of nesting birds and foraging bees when spraying trees.

2. b. Increasing the spray pressure will reduce droplet size. Small droplets are more likely to drift.

3. To prevent bystander exposure to pesticides:

   a. Post public notices stating where and when treatments are planned, or have occurred.

   b. Keep to all provincial and municipal requirements for public notice (e.g., posting, direct contact with nearby property owners).

   c. Use pesticides during periods of low public activity. Use weekends for school grounds. Use early morning for parks.

   d. Avoid spraying near public roadways.

   e. Tell owners or occupants of private land what to do to prevent exposure.

4. True.

5. a. and b.

Chapters 5 through to Chapter 8: Integrated Pest Management and Pests (Various)

1. Two of the following:

   - Begin with a small site
   - Choose a site with few pests
   - Choose one pest or group of pests

2. Gathered information should include:

   - Past records of pest problems or treatments
   - Regulatory requirements or local bylaws that apply
   - All treatments that can be used

- Money and other resources that can be used for an IPM program
- Initial site assessment information

3. Sticky traps also attract beneficial species.

4. Two main ways, in an IPM program, to use natural enemies of pests are:
   - Conserve and attract native species.
   - Purchase commercial species and release them.

5. They clog breathing systems of insects and mites. They can also disrupt egg membranes and keep them from hatching.

6. They have the least impact on natural enemies of pests.

7. To prevent weed problems:

   - Design hard surface areas to eliminate weed zones
   - Avoid bringing weed seeds into sites
   - Care for desired plants so they can compete with weeds
   - Sow competitive plants or aggressive ground covers

8. You must diagnose and correct conditions that cause disorders. Plants weakened by stress are more likely to be attacked by pathogens or insects. They may also be less able to compete against weed infestations.

9. Dormant spores are least likely to be affected by a fungicide.

10. True.

11. False.

12. False.

Chapter 9: Application Technology

1. Hand held pressure sprayers, backpack sprayers, boom sprayers, power hose sprayers, wick applicators, and tree stem injectors.

2. Sprayer parts include:

   - Spray tank
   - Pumps
   - Agitators
   - Strainers
   - Controls
   - Pressure gauge
   - Plumbing
   - Structural framework (including boom design)
   - Nozzles
   - Clean water tank (for decontamination)

3. b.

4.

   - Set-up the sprayer.
   - Measure the equipment application rate.
   - Make adjustments. Correct equipment application rate and volume if needed.
   - Figure out the amount of pesticide to add to the spray tank (Pesticide Use Calculations).

5. Three factors are:

   - Spray width (or nozzle spacing)
   - Total nozzle output (or average nozzle output)
   - Travel speed

6. Weather factors:

   - Air and ground temperature

- Relative humidity
- Wind speed and direction
- Forecast weather conditions

7.

- Increase droplet size by lowering pressure
- Select a low drift nozzle
- Use a coarse spray quality (droplet size)
- Lower boom height or hold the spray gun closer to the target. Nozzles can be tilted forward to maintain recommended boom height for proper overlap and uniform application. Note: Lowering the boom by using nozzles with wider spray patterns, and finer droplets, may not reduce drift
- Use a spray guard or shroud
- Use equipment to reduce or stop drift (e.g., wick application equipment)
- Use drift control agents

8.

- Rinse the equipment at the end of each spraying day. Flush clean water through the pump, hoses, and nozzles
- Check all screens, strainers, and nozzles. Clean them if needed
- Check the sprayer for wear. Replace worn or damaged parts
- Wash the sprayer. Dispose of rinsate where residues will not cause environmental harm
- Follow label directions and provincial laws

Check the:

- Agitator
- Regulator
- Pressure gauge (for accurate operation)
- Couplings and clamps (for proper seal)
- Hose flex points (for wear)

9. Main parts:

- Storage hoppers
- A metering mechanism
- A distribution system

10. Treatment width equals the total of all individual band widths for one pass.

11. Mix them into the soil.

12. Steps include:

    - Cleaning the equipment
    - Lubricating all moving parts
    - Following the manufacturer's guidelines
    - Checking and replacing worn parts
    - Storing equipment where it will not be damaged by other equipment, livestock, or weather

Chapter 10: Professionalism

1. True.

2. Ways include:

    - Avoiding pesticide applications in schoolyards when children are present
    - Applying pesticides in residential areas with little human presence
    - Applying pesticides to commercial and public property during off-hours or times of reduced traffic

APPENDIX B:

INSECT FACTSHEETS

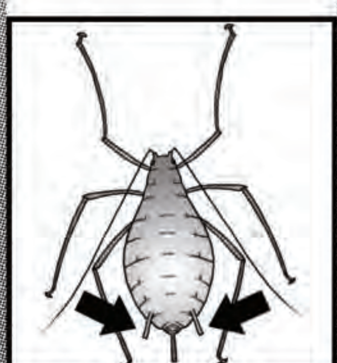
Ornamental Insects

Aphids (Various species) Homoptera: Aphididae

Description

Adults and Nymphs

Aphids are 2-8 mm long, pear-shaped sucking insects with long antennae. Colours may be green, grey, pink, yellow, dark brown or black.



Key Characteristics

Look for “cornicles”. They look like stubby “tailpipes”. These point backward from the tip of the abdomen (see figure). Some aphid species produce a white “fluff” (waxy secretion). The aphids will be found under the fluff.

Host Plants

Rose, maple, willow, viburnum, apple, cherry, and other ornamentals

Damage

Aphids suck plant sap. This causes distorted leaves, buds, and branch tips. Aphid feeding can also cause leaves to drop. Aphids excrete honeydew when they feed. This sweet, sticky liquid drips onto the leaves and objects below. It leaves a sticky mess when it lands on cars and sidewalks. It also attracts yellow jacket wasps. Sooty molds often grow on the honeydew, and cause blackened streaks on leaves and tree trunks.

Biology and Life Cycle

Most species of aphids live in colonies. When they become crowded, winged aphids appear and fly off to start new colonies.

Most aphids spend winter as eggs laid on stems, branches, or other plant parts. In the spring, the eggs hatch into female aphids. These give birth to live aphids all season without mating or laying eggs. In the fall, these females give birth to “true” males and females. This last generation mates and lays eggs that over winter. In indoor gardens, aphids can reproduce all winter.

Most aphid species only attack a few closely related plants. For example, aphids found on roses may move to other roses. There is little risk of them moving onto other plants such as fruit or maple trees. Some species of aphids move between two host plants. For example, the bird cherry-oat aphid moves between wild cherry and young cereal grain plants. A few, such as green peach aphid, have a wide range of hosts.

Monitoring

Check plants frequently (e.g., weekly). Look for droplets of honeydew. These form shiny, and sticky patches. Look for distorted or curled leaves and branch tips. Use a 10X or 15X magnifying lens to look for aphid colonies. Look These are often found under the oldest leaves and on the newest foliage.

Aphids have many natural enemies. These may be predators or parasites. Look for all life stages of these enemies among aphids. References with pictures of aphid natural enemies are given at the end of the IPM chapter.

Counting Methods

Roses and other plants

Count the number of branch tips, leaves, or plants with aphids. Start checking the most susceptible plants in the spring, a few weeks before you would expect to see aphids. Check 5-10 leaves (or shoots or plants) every 1-2 weeks. Record the number with and without aphids. Do this each week and tally the counts. Inspect a number of plants in each area. Count aphid predators at the same time. This information can be used in setting thresholds. Keep records of when and where aphids first appear each year. This helps pinpoint the best time and place to start looking for them in the future.

Boulevard trees

Place cards under the foliage**.** Count the number of honeydew droplets falling on the cards during a given time period (e.g., a half hour, 2 hours, 4 hours). Special, water-sensitive cards used to monitor spray drift can be used. Cards made of acetate or dark construction paper will also work. Cards should be set out in midday. Attach cards to clipboards placed on the ground beneath the tree, or clipped to lower branches.

Injury and Treatment Thresholds

The following are examples of injury thresholds used by some landscape managers:

- For background plants, where falling honeydew is not a problem, the injury threshold is 20-40% of leaves with aphids.
- For roses, the injury threshold is 5-10% of branch tips infested.
- For other plants, the injury threshold is less than 1 aphid predator per 50 or more aphids. For example, if more than one life stage (egg, larva, or adult) of an aphid predator is seen among 50 aphids, there is no need to treat. These levels of natural predators are high enough to control the

problem. Aphid predators include lady beetles, aphid midges, syrphid flies, lacewings and parasitic wasps.

- If honeydew is the main problem caused by aphids, an injury threshold can be based on the number of honeydew drops falling on monitoring cards per hour. If the honeydew is falling on plants and sidewalks, the threshold number of drops can be higher than when honeydew is falling on parked cars.

Treatments

Physical Controls

Prune out infested foliage. Remove aphids by spraying plants with a strong stream of water. Knocking aphids off plants with water damages their mouthparts. Few will be able to go back to the plant and feed again. This works best if the treatment is repeated a few days apart. This catches any aphids that may have survived the first spray.

Biological Control

Many aphid biological controls occur naturally. Biological control species may be drawn to landscapes by flowers that provide pollen and nectar.

Commercial biological control species can be bought from vendors. The aphid midge (*Aphidoletes aphidimyza*) is a common native species that can be used outdoors in roses, shrubs, and boulevard trees. Ladybeetles are also sold. The species most widely sold, *Hippodamia convergens*, often flies away when released. These are not suited for outdoor use, unless the release is carried out over a very large area. These can be released indoors, if vents are screened to keep beetles inside. For biological controls, the time to release predators is early spring. This should be done once aphid colonies are found. Check with biological control vendors for advice on release rates, timing, and handling methods.

Chemical Controls

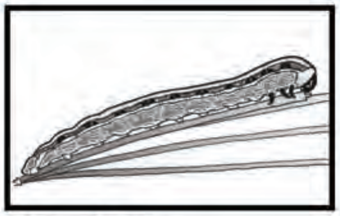
Insecticides are rarely needed to control aphids. They are difficult to control with insecticides. Leaf coverage must be very thorough. Aphid populations quickly become resistant to pesticides that are used too often.

Avoid using residual insecticides, especially as foliar or broadcast sprays. These will have long-term effects on aphid predators. This can lead to more severe aphid infestations in the future. Non-residual insecticides for aphids include:

- Spot sprays of insecticidal soap, insecticidal soap with pyrethrins, or pyrethrins alone
- Horticultural oils applied as spot sprays on growing foliage
- Dormant oil sprays to aphids eggs over wintering on deciduous trees
-

Check municipal and provincial permit or approval requirements before commercially applying insecticides to boulevard trees and other public use areas.

Ornamental Insects



Description

Adults
Adult sawflies are stout, wasp-like insects (2-3 cm long). They have two pairs of clear wings. Females have a saw-like appendage on the abdomen. This is used to insert eggs into foliage.

Larvae
Most sawfly larvae look like small caterpillars.

Sawflies (Various species) Hymenoptera: Tenthredinidae, Diprionidae

Key Characteristics

Both sawflies and caterpillars have prolegs. Prolegs help larvae move around and adhere to plant surfaces. Sawflies have 5 or more pairs of soft, fleshy, false legs or "prolegs" (see figures) on abdominal segments. Caterpillars have 2-5 pairs of prolegs. It is important to be able to tell the difference between sawfly larvae and caterpillars. There is an effective microbial pesticide for caterpillars *(Bacillus thuringiensis kurstaki*). However, this product has no effect on sawfly larvae.

Host Plants

Two main groups of sawflies cause problems in landscapes. "Conifer" sawflies attack conifers (e.g., pine, spruce, and larch). "Broadleaf" sawflies attack broadleaf plants (e.g., roses, alder, birch, willow, and pear).

Damage

Conifer sawfly: Conifer sawfly larvae often feed on needles or buds. Some mine into tips and shoots, causing dieback.

Broadleaf sawfly: Broadleaf sawfly larvae often start by chewing small holes between the veins of leaves. Larger larvae chew large irregular holes in leaves. Some broadleaf sawflies also start by mining in leaf tissue. This leaves discoloured, winding tunnels. The rose sawfly, or roseslug (*Endelomyia spp.*) skeletonizes the lower leaves of the rose.

Biology and Life Cycle

Sawflies have four life stages; egg, larva, pupa and adult. Depending on species, the larvae hatch from the late spring to early summer. The larva feed heavily for 30-40 days until they mature. Some species feed singly while others feed together in colonies.

Mature larva drop to the ground to pupate. Conifer sawflies overwinter just beneath the soil surface in cocoons. Most broadleaf sawflies spend winter as eggs in foliage or pupate in an earthen cell or leaf litter below the host plant.

Some sawfly species have more than one generation per year.

Prevention

Conifer sawflies attack stressed or weakened trees. For example, yellow headed spruce sawflies often attack young, isolated spruce trees. Those in wet conditions or on south slopes are at risk. Prevention includes:

- Choosing other trees that are better suited to the site, such as larch ("tamarack")
- Draining waterlogged sites
- Planting spruce among other trees, in groups

Make sure that conifers from nurseries are not infested. Pre-treat stock trees before planting in permanent sites.

Broadleaf sawflies also do the most damage to stressed trees and shrubs. Keeping plants healthy will help prevent sawfly damage.

Monitoring

Conifer Sawflies: Inspect needles in early spring. Look for signs of mining or tiny feeding larvae. From a distance, this may appear as a discolouration on the tips and shoots. Monitoring times for specific sawflies are as follows:

- In May, look for red pine sawfly on jack pine and red pine.
- In June, look for balsam fir sawfly, European spruce sawfly, and larch sawfly.
- In July, look for yellow headed spruce sawfly.

Broadleaf sawflies: Start looking for leaf mines in June. Look for early signs of skeletonizing. This starts as very small patches on leaves. When larvae are found, make sure they are sawfly larvae, and not caterpillars. To do this count the prolegs. Sawfly larvae have more than five pairs of prolegs on the abdominal segment, while caterpillars have two to five pairs.

To sample for sawflies:

- Shake or beat foliage over beating trays. Count the larvae that drop.
- Count the number of damaged tips (for conifers).
- Check trees that tend to show infestations first (indicator trees).

Injury and Treatment Thresholds

For some conifers, especially those growing in poor conditions, treatments may be needed as soon as damage is found. Others can withstand moderate populations without showing signs of damage.

A large number of sawflies may live on broadleaf trees without causing long-term damage. They may cause an unsightly appearance. If insecticides are needed, they should be applied when the first generation is present. Later generations cause little additional damage. If tree damage reaches an unacceptable level by late summer, treatments should be planned for the next spring.

Treatments

Physical Controls

Sawflies are relatively easy to knock from the foliage with a stick. They do not climb back up. Roseslug, pearslug, and other "broadleaf" sawflies can be washed from leaves with a strong stream of water. For smaller trees and shrubs, this method may be enough to minimize damage and protect natural enemies.

Remove lightly infested tips of conifers.

Biological Control

Sawflies have many natural enemies. These include parasitic wasps and birds. Sawflies are often controlled by predators in mixed landscape plantings. There are no commercially available biological control species for sawflies.

Chemical Control

Insecticides should not be used to control roseslug (rose sawfly). This can harm aphid predators and cause an aphid outbreak. Water sprays work best for roseslug.

For conifer sawflies, use low toxicity insecticides (e.g., insecticidal soap, spinosad, and azadiractin). Some products with carbaryl, methoxychlor, or permethrin may be used on some sawflies. These are more harmful to beneficial insects than low toxicity products.

Ornamental Insects

Description

Adults

Adult fall webworms are white moths with 5-6 cm wingspans. Their Fore-wings have fine black dots. The abdomen of the moth is yellow with black spots.

Larvae

The larvae are pale yellow, hairy caterpillars, up to 2.5 cm long. They have one broad black stripe on their backs with a yellow stripe on either side.

Fall Webworm (*Hyphantria cunea*)
Lepidoptera: Arctiidae

Key Characteristics

Larvae spin, loose silken nests. They feed inside. Webworms are often confused with Eastern tent caterpillars. Tent caterpillars feed on trees in May and early June. Their nests are smaller and in the crotches of branches. Webworms feed later in the summer. Their nests are large, loose and spun over the ends of branches.

Host Plants

Fall webworm caterpillars feed on fruit trees and other deciduous trees and shrubs. These include speckled alder, Manitoba maple, cherry, apple, and elm along roadsides.

Damage

Defoliation causes little damage to the trees. Webs can be large and unsightly.

Biology and Life Cycle

Adults emerge from early July until early September. Eggs are laid soon after emergence. Each female adult lays from 400-500 eggs in one mass. They are often found under a leaf at the end of a branch. Eggs hatch in about two weeks. The young larvae, as a group, spin a loose tent of silk over the leaf. They feed for about six weeks. The tent gets bigger until it covers a whole branch, or the top of a tree. Webs are easy to see from late July to early September. At the end of the feeding period, larvae move from the nest to pupate and overwinter. Webworm pupae spend winter in leaf litter or under tree bark. There is one generation per year in Atlantic Canada.

Monitoring

Look for eggs on branches in mid-summer. They are laid in masses and covered with yellow hair. Later in the summer, look for small silken nests on the ends of branches.

Injury and Treatment Thresholds

Webworm feeding rarely affects the long-term health of deciduous trees. Treatments are only required to preserve the appearance of high value ornamental plants. Finding nests early allows them to be removed by pruning or by hand before damage appears. Control is not needed on roadside shrubs, farm windbreaks, or in waste areas. Appearance is not a concern in these cases.

Treatments

Physical Controls

It is often enough to remove nests. This can be done by pruning. Nests can be pulled out of foliage using a long stick with a few large nails driven into the tip.

Biological Controls

Naturally occurring natural enemies include:

- Parasitic wasps and flies
- Natural caterpillar diseases that attack webworms

Populations can vary from year to year. Natural enemies control webworms in a 5-10 year cycle.

The microbial pesticide, *Bacillus thuringiensis kurstaki* (BTK) can be used to control the caterpillars. It must be applied while larvae are small or just as larvae are starting to leave their nests to feed. Larvae feed inside the web most of the time. This protects them from most pesticides.

Chemical Controls

Insecticidal soap and growing season oil sprays can be applied using the same timing as for BTK described above. Malathion can also be used.

Ornamental Insects

Birch Leafminer (*Fenusa pusilla*)
Hymenoptera: Tenthredinidae

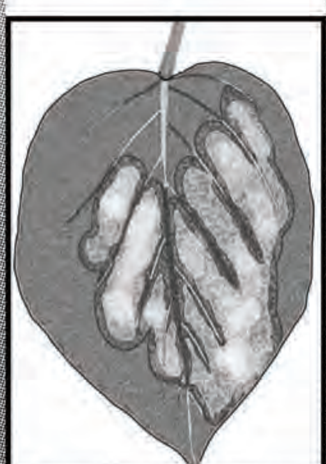
Description

Adults

Adult birch leaf miners are black four-winged sawflies, about 3 mm long.

Larvae

Larvae are tiny, flattened, pale green larvae.



Key Characteristics

Larvae are leaf miners. They feed between the upper and lower surface of leaves.

Host Plants

Wire birch, white birch, yellow birch, and European cut-leaf birch

Damage

Larval feeding causes brown blotches on leaves. Leaves may turn completely brown in severe cases.

Biology and Life Cycle

The birch leaf miner has three generations a year. Sometimes there is a partial fourth. It spends winter in a cocoon beneath the surface, at the base of an infested tree. Adults emerge in the spring when leaves come out (May 24^{th} to June 15^{th}). Each female lays 3 to 15 eggs in the tissue of a leaf. Eggs hatch in 6 - 10 days. Larvae feed inside the leaf for 10-15 days. They then emerge from the leaf and drop to the ground. The larvae spin cocoons and pupate in the soil. The next generation of adults emerge in about 20 days. There is overlap of generations. Mines may be present in leaves from May to September.

Prevention

Avoid planting birches in areas with a history of leafminer damage. Plant birches among other trees. Leafminer attacks are worse on open-grown birches.

Monitoring

Start soon after leaves unfold (late May and June). Check trees for the first sign of eggs. Eggs are laid in slits in the new leaves. The first symptoms of damage are gray areas in the leaf tissue around the eggs. Olive-green translucent blotches appear after eggs hatch. These become larger and the entire leaf may be destroyed in time. Mining begins near the mid-rib. It moves out toward the edges of the leaf.

Injury and Treatment Thresholds

Leafminers prefer young tender leaves that appear early in the season. As a result, the first generation causes the most damage. If insecticides are used, they should be targeted to the first generation in early spring. Late season insecticide applications are of little use. Later generations often attack younger leaves at the top of the tree and at the ends of the branches. The damage has been done for the season. Spraying will not improve tree appearance. If tree damage reaches an unacceptable level by late summer, treatments can be planned for the next spring.

Treatments

Biological Control

Predatory insects, parasitic wasps, and birds are natural enemies of leafminers. Minimize harm to beneficial species when choosing a control. This will help with future leafminer control.

Chemical Control

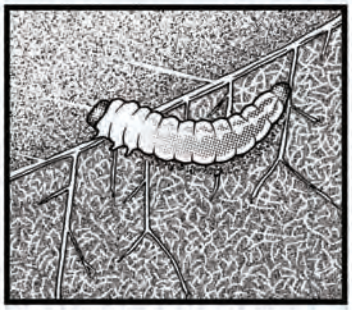
Larvae feed between the upper and lower leaf surfaces. They cannot be killed with ordinary contact and stomach poisons. These pesticides do not penetrate leaf surfaces.

- **Banding with Insecticide:** Trees can be banded with a systemic insecticide such as dimethoate. Paint the undiluted pesticide in a band around the tree trunk. Width should equal tree diameter, but not exceed 16cm. Paint just below the lowest branch. This should prevent serious injury for about five weeks. Trees should be treated when buds begin to open (April 25th to May 15th). If a systemic insecticide is used more than once a year, applications should be made at different places on the trunk. Do not treat stems less than 3cm in diameter.

- **Soil Drenching with Insecticides**: One soil drench treatment per year is enough to control leaf miner. This method may not work on newly transplanted birches. Their root systems are not well established to take up the product properly.

- **Spraying with Insecticide**: Spraying works best when applied 10-15 days after the eggs hatch. Look closely at the foliage for small pinpoint blisters on leaves. This period is roughly May 20th to June 10th. Repeat the application in seven days. Two repeat applications six weeks later may help (roughly July 10th and July 25th). This controls the second generation of sawflies.

Ornamental Insects



Description

Adult

The adult lilac is a brown moth, about 6 mm long.

Larvae

Larvae are pale yellow caterpillars, 6 mm long.

Lilac Leafminer (*Caloptilia syringella*)
Lepidoptera: Gracillariidae

Key Characteristics

Larvae mine and roll the leaves. Several may be found feeding on the same leaf.

Host Plants

Lilac, privet shrubs, or hedges

Damage

Feeding first shows up as small, discoloured spots. Mines later become large blotches. Leaf damage often causes complete browning of foliage. This can be confused with lilac blight or effects of poor growing conditions.

Biology and Life Cycle

Moths emerge from late May to early June and lay eggs on the underside of leaves. The eggs hatch in 7-10 days. Larvae burrow into the leaves causing small discoloured spots. Larvae come out of the leaves in about three weeks. They then roll up a portion of leaf and feed inside it. About 10 days later, they drop to the ground. Leaf miners pupate in the debris, just below the surface. About two weeks later (early August), a second generation of moths appears. The life cycle repeats. Feeding by the second generation goes on until about mid-September. Mature larvae drop to the ground. They spend winter as pupae in the soil beneath infested plants.

Prevention

If lilacs are repeatedly infested, consider replacing them with other plants.

Monitoring

Start soon after leaves unfold in late May and June. Check foliage for the first signs of egg laying. Tiny white eggs are laid in groups of 5-10 on the underside of the leaves. These are mainly found where leaf veins cross.

Injury and Treatment Thresholds

Leafminers prefer young tender leaves that appear early in the season. The first generation causes the most damage. Insecticides should target the first generation in early spring. Later generations often attack younger leaves at the top of the tree and at the ends of the branches. Late season insecticide applications are of little use. The damage has been done for the season. Spraying will not improve tree appearance. If tree damage reaches an unacceptable level by late summer, treatments can be planned for the next spring.

Treatment

Physical Controls

Remove and destroy infested leaves at the first sign of egg laying in late May. This may work on shrubs that are small enough to reach.

Chemical Control

Larvae are hard to kill. They feed in between the upper and lower leaf surfaces. Ordinary contact and stomach insecticides cannot reach them.

Systemic insecticides can be applied in a 7cm band around the stem. The band should be 30cm above the ground. This will control leaf miners for about four weeks. Two applications will be needed. The first is needed when leaves appear (around the last week in May). The second is needed during the last week in July.

Foliar insecticide sprays can be used before adults emerge. Apply spray right after the leaves flatten out (last week of May to first week in June). Repeat treatment for the second generation (during the last week in July). If spraying is delayed until blotches appear, control will be less effective.

Ornamental Insects

Elm Leafminer (*Fenusa ulmi*)
Hymenoptera: Tenthredinidae

Description

Adults

Adult elm leafminers are small sawflies, 3 mm long.

Larvae

The larvae are pale white or green larvae, up to 2-3 mm long.

Key Characteristics

Larvae mine leaves. They feed between the upper and lower surface of leaves.

Host Plants

Host Plants are mainly English and Scots elm and the Camperdown variety. White elm may be attacked.

Damage

Severe infestations turn trees completely brown. Severe leaf browning has been reported in Nova Scotia in the Annapolis Valley and in Halifax. In New Brunswick, cases have been recorded mostly in the Sackville, St. Andrews, and Baie Verte areas.

Biology and Life Cycle

Adults emerge from late May to early June when leaves are unfolding. Eggs are laid in the leaf tissue. They hatch about 10 days later and begin feeding in the leaf. Larvae mature by late June or early July. They drop to the ground and spin cocoons in the soil. Larvae spend winter in cocoons in the soil. There is only one generation per year.

Monitoring

Blotches in leaf tissue between veins are early symptoms of attack. These blotches turn brown. Some drop out and leave holes in the leaves.

Injury and Treatment Thresholds

Leafminers prefer young tender leaves that appear early in the season. The first generation causes the most damage. Insecticides should target the first generation in early spring. Later generations often attack younger leaves at the top of the tree and at the ends of the branches. Late season insecticide applications are of little use. The damage has been done for the season. Spraying will not improve tree appearance. If tree damage reaches an unacceptable level by late summer, treatments can be planned for the next spring.

Treatments

Physical Controls

Remove and destroy infested leaves at the first sign of egg laying in late May. This may work on shrubs that are small enough to reach.

Chemical Control

Larvae are hard to kill. They feed between the upper and lower leaf surfaces. Ordinary contact and stomach insecticides cannot reach them.

Systemic insecticides can be applied in a 7cm band around the stem. The band should be 30cm above the ground. This will control leaf miners for about four weeks. Two applications will be needed. The first is needed when leaves appear (around the last week in May). The second is needed during the last week in July.

Foliar insecticide sprays can be used before adults emerge. Apply spray right after the leaves flatten out (last week of May to first week in June). Repeat treatment for the second generation (during the last week in July). If spraying is delayed until blotches appear, control will be less effective.

Description

Adults

Adult antler moths are reddish-brown moths with a 2-3cm wingspan. They have a central mark on each forewing that looks like an antler.

Larvae

The larvae are dark brown cutworms, 3-4 cm long. They have brown heads, wrinkled skin, and yellow-white lines down the sides and back.

Antler Moth (*Cerapteryx graminis)*
Lepidoptera: Noctuidae

Key Characteristics

Unlike other cutworms, antler moth larvae are active during the day. They can be found feeding or moving in groups.

Host Plants

Larvae feed on roots, shoots, and leaves of grasses. Native to Europe, the antler moth was accidentally introduced to Newfoundland. It was first recorded in Mount Pearl in 1966. By 2002 it had spread across the Avalon Peninsula and as far as Port Rexton. It only occurs on the island part of Newfoundland and Labrador. **The Antler moth has not been reported in other parts of Atlantic Canada.**

Damage

High numbers can cause large dead areas in turf.

Biology and Life Cycle

Antler moths overwinter as eggs. These hatch in late April or May. Larvae feed on grasses until they reach full size. Large groups of larvae sometimes move across lawns, sidewalks, and driveways. Adults fly from June to September. Antler moths fly during the day and night. They are drawn to lights at night.

Antler moths spin cocoons from early July to early August. After about ten days, moths emerge from cocoons. After mating, each female lays 250-500 eggs. Egg survival is favored by a cool humid fall, followed by a cold snowy winter.

Prevention

Healthy turf will heal more quickly from attack than stressed turf. Over-seeding may be required to repair badly damaged areas. This will prevent weeds from growing in the damaged areas.

Monitoring

Unlike other cutworm larvae, they are active during the day. They tend to stay in groups. In naturalized areas, they can be found under rocks.
Larvae are easy to see due to their size and behavior. If damage appears in midsummer, but no larvae are found, it can mean they have left the area to spin cocoons. It can also mean that the damage was caused by something else.

Injury and Treatment Thresholds

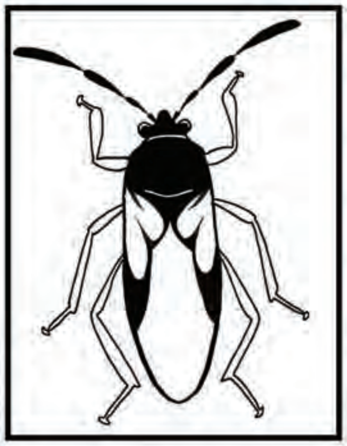
Insecticides should be used when larvae are feeding (in early summer). Antler moth feeding can seriously damage lawn turf in Newfoundland. Treatments may be needed to preserve the appearance of lawns.

Treatments

Chemical Control

Contact insecticides (e.g., insecticidal soap and pyrethrins) may control larvae. Carbaryl and permethrin are more toxic controls. Chlorpyrifos, an insecticide once used on lawns, can no longer be used on residential lawns.

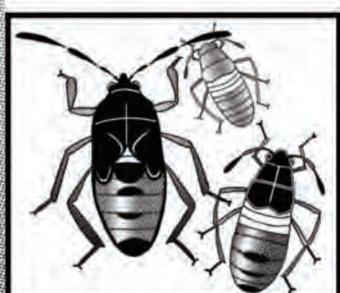
Hairy Chinch Bug (*Blissus leucopterus hirtus*) Heteroptera: Lygaeidae



Description

Adults

Adult Cinch bugs are oval insects, about 4 mm long. They are dark, with white wings folded flat across the back.



Nymphs

When they hatch, nymphs are tiny and bright red, with a white band across the back. Their colour darkens as they grow and pass through five moults. The last nymphal stage before adult stage is almost black.

Key Characteristics

They are quick-moving insects with small eyes. Their main predator is the big-eyed bug. It is similar in shape and size, but has large, prominent eyes.

Host Plants

Both adults and nymphs damage turfgrass. They pierce and suck sap from leaves and crown. Their saliva contains a toxin that is injected into the plant as they feed. This often kills the plant.

Damage

Chinch bug damage closely resembles drought stress. The damage first appears as yellow patches in the lawn. These continue to expand. Turf later dies and turns brown. Lawns not watered in the summer may not show damage until rains start in fall. Chinch bug damage is most common on warm open areas and dry slopes.

Biology and Life Cycle

Adult chinch bugs spend winter in sheltered areas (under trees and shrubs) and in long grass. When it warms in the spring, they become active and start laying eggs (May and June). Females lay 200-300 eggs. They are laid in small groups in the crowns of the grass plants inside the base of the leaf sheaf. This is inside the base of the leaf sheath above the crown. Eggs take over a month to hatch. Nymphs develop into adults in July and August. They spend winter as adults. In the Atlantic region, there is likely only one generation per year. There have been scattered reports of a second generation in the most southern areas.

Nymphs seem to prefer sunny and dry areas of lawns especially where the soil is compacted. Wet conditions and high soil moisture may control early nymphal stages. Chinch bug feeding occurs throughout the season, but it may not become visible until late summer. Dry conditions and drought stress increase damage.

Prevention

Grow vigorous, healthy turf, in well-aerated soils. Prevent drought stress. Chinch bug damage can be more severe in drought stressed turf. Research is being carried out to determine which turfgrass species and cultivars resist chinch bug damage.

Manage thatch to ensure that it does not become too thick. Some researchers believe that thick thatch can promote chinch bugs. A recent Quebec study did not find this link. Excess thatch does make it hard to find and manage chinch bugs.

Turfgrass mixtures containing grasses that are infected by beneficial endophytic fungi can help turf resist damage. These fungi are toxic to leaf and crown feeding insects. They can help control chinch bugs.

Monitoring

- **Quadrat Method**: A sampling technique for chinch bugs was developed at Laval University. It has showed promise for use in Atlantic Canada. Place a $0.1m^2$ frame on the turf and count all insects seen in the quadrat for one minute. This test should be done weekly from late June to late July. Use three quadrat counts per $100m^2$ of lawn.

- **Flotation Method**: Remove both ends of a tin can. Push it 5cm into the turf. Pour soapy water into the can. All stages of chinch bugs float and can be counted after 10-15 minutes.

Injury and Treatment Thresholds

Chinch bugs only cause noticeable damage on some lawns. Their presence does not always require treatment.

Injury thresholds are being developed and refined for Atlantic Canada. The following are examples of injury thresholds. Stressed turf can be damaged by lower numbers of chinch bugs. Consult university or agricultural extension experts for more recent research.

- **Using the flotation method,** damage has been found to occur at 35 chinch bugs (all stages) per square foot.

- **Using the quadrat method,** damage occurs when an average of 10 or more chinch bugs are counted per quadrat.

Treatments

Cultural Control

Cultural Controls improve turf health. Proper watering helps it recover quickly and show less damage from chinch bugs.

Biological Control

Native predators (e.g., big-eyed bugs) attack chinch bugs. These insects occur naturally and are not commercially available. The fungus (*Beauveria bassiana*) is being studied for development as a biological control.

Chemical Control

Chinch bug damage is usually very patchy. Insecticide spot treatments are only required in areas where counts exceed injury thresholds. Spot treating infested or damaged areas in otherwise healthy turf provides good control. Avoid application to the whole turf area. This helps preserve naturally occurring predators.

Insecticides have less effect in dry conditions. Control may be improved by irrigating to moisten soil before and after application. Some pesticides containing carbaryl are used to control chinch bugs.

Pesticide treatments work best when applied to the insect in the 3rd instar stage. Most of the eggs will have hatched by this time. Few nymphs will be at later stages that are harder to control with pesticides. Treatments applied too early or too late will give poor control. These will also reduce populations of beneficial insects that attack chinch bugs.

White Grubs (*Phyllophaga* spp.)
Coleoptera: Scarabaeidae

Description

Adult

Adult june beetles are blocky, shiny reddish brown insects, up to 2cm long. They are found in May or June.

Larvae

Full-grown larvae may be up to 1.2cm long. They are white to gray, with a brown head and 6 distinct legs.

Key Characteristic

Larvae usually curl into a "C" shape when disturbed. They are found in the root zone of plants.

Host Plants

Plant roots, particularly turf.

Damage

Healthy turf may not show damage, even when pest numbers are high. Occasionally, damage can be severe, resulting in brown dead sections. White grubs do not destroy the crown of the turf plant. Turf with light grub damage will often recover.

In some cases, skunks, raccoons, and birds cause the only damage that can be seen. They tear out turf to get at large grubs. Control programs can focus on managing these animals (live trapping, startle devices, screening, etc.).

Biology and Life Cycle

In Atlantic Canada, only one type of white grub, the May/June beetle has been found damaging turf. White grubs take 3 years to develop from an egg into a mature beetle. Adult beetles emerge from the soil in late spring and mate. Eggs are laid beneath the soil surface. When larvae hatch, they feed on rotting organic matter during summer. They burrow into the soil for winter. In the second summer, they feed on plant roots. They spend the next winter deeper in the soil. In the early spring, they again rise to the root zone to feed. In May or June of the third summer, they pupate and stay in the soil until spring. They then emerge as adults.

Prevention

Spreading manure on turf in summer attracts adults to lay eggs. If this practice is planned, wait until later in the summer **or** compost the manure and apply as a top dressing early in spring.

Monitoring

Cutting a square foot section of turf will show the number of larvae feeding on plant roots. Cut turf along three sides. Fold back the sod to expose the roots. The larvae are large and easy to count among plant roots. After counting, the section of sod can be replaced with little damage to turf.

Injury and Treatment Thresholds

Larvae cause the most damage during the second summer. At this time, they are feeding on plant roots. Little work on thresholds has been done. A small study from Maryland suggests that 5-7 larvae per square foot can damage turf stressed by drought.

Treatments

Physical Controls

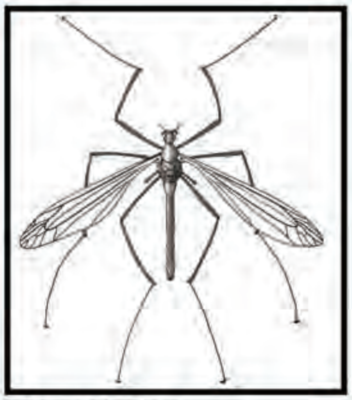
Soil aeration may kill a number of larvae in the root zone.

Biological Controls

Natural predators attack eggs and young larvae. Some insect parasite nematode species may attack white grubs. These have not been commercially available. Species that attack root weevil larvae or other pests may not affect white grubs. The fungus *Beauveria bassiana* is being studied for use as a biological control.

Chemical Controls

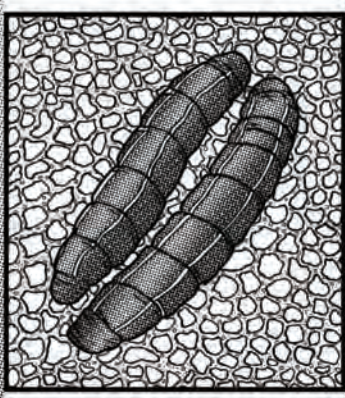
Some products with carbaryl can control white grubs. Diazinon and chlorpyrifos were used for white grubs in the past. These products are no longer registered for use in or around homes.



Description

Adults

Adult crane flies are large, light brown flies up to 2. 5cm long. They look like giant mosquitoes. They have long, fragile legs.



Larvae

Crane fly larvae, called leatherjackets, are dull gray, legless maggots. They measure up to 3cm long when full grown.

Leatherjackets / European Crane Fly (*Tipula paludosa*) Diptera: Tipulidae

Key Characteristics

Maggots and pupae are large. They are gray and leathery. The large size of adults and their poor flying makes them easy to see among flying insects.

Host Plants

Larvae feed on roots and crowns of turf and pasture grasses.

Damage

In severe cases, feeding causes ragged, brown patches in turf (in the spring). The symptoms od a moderate infestation of crane flies are not distinctive. They can easily be confused with damage from other sources such as drought, excessive wear or fertility problems. Severe infestations resulting in turf death are rare in Atlantic Canada.

Biology and Life Cycle

Female crane flies lay eggs in turf from August to September. Larvae feed among roots for 1-2 months in the fall. They cause little damage because of their small size. The larvae spend winter in the soil. Many are killed by natural enemies and winter weather. Survivors begin feeding in early spring. They grow to full size by mid-June.

Larvae stop feeding for a few weeks and pupate in early July. Adults emerge from August to September.

Prevention

Damage is usually noticeable on stressed or highly managed turf (e.g., golf greens). Maintaining good healthy turf helps prevent damage from leatherjackets.

Monitoring

The following are ways to monitor for leatherjackets in turf:

- In early spring, find a $1m^2$ area of turf showing damage. Drench it with soapy water (lemon scented dish soap works best) , or water with a small amount of pyrethrins insecticide. Count the leatherjackets that wiggle to the surface. After counting, rinse the treated area with water to avoid damage to grass plants.
- In spring or fall, pull back sections of sod (e.g., cut one square foot on three sides). Pick through the soil and roots to count larvae and pupae. Replace the sod sections.
- Cut sections of damaged sod. Soak in a saturated solution of salt water. Count the larvae that float to the top. This method will damage the sample sod.
- Larvae can sometimes be seen feeding on the surface of close cut turf in the early morning.

Injury and Treatment Thresholds

Injury levels for leatherjackets used by turf managers are given below:

- For high profile, high maintenance sites, injury threshold occurs at 20-25 larvae per m^2 in spring.
- For intermediate sites, injury threshold occurs at 50-100 larvae per m^2 in spring.
- For natural or low care sites, injury threshold occurs at over 100 larvae/m^2 in spring or 300 larvae per m^2 in fall. The higher level in the fall is allowed because many larvae die over winter.

Required treatments should be timed from April to early June. These affect larvae when they are feeding on roots.

Treatments

Biological Control

Reduce the use of insecticides to protect species of mites, ants, beetles, and other predators. These feed on crane fly eggs and larvae. Insect parasitic nematodes may become available to control leatherjackets. It is not clear how well these work in Canada. Always follow label guidelines for release rates and timing.

Chemical Control

Some products with carbaryl control leatherjackets. Diazinon, once used for leatherjackets, is no longer registered for use on turf in residential areas.

APPENDIX C:

GLOSSARY

Glossary

Acetyl cholinesterase

An enzyme in the blood. It breaks down acetylcholine in a nerve gap. This leaves it ready for the next message to be transmitted across the nerve gap.

Action threshold

The point at which treatment should take place to prevent a pest from causing harm. Timing depends on the type of treatment selected.

Active ingredient

The substance in the pesticide that controls the pest.

Acute toxicity

An adverse effect or response. It is seen in a person within a few hours to several days after exposure.

Aerosol pesticides

Small, pressurized contains a pesticide. It releases the pesticide through small holes. Spray is pushed out by an inert gas under pressure. When the nozzle is triggered, it makes a very fine spray, mist or fog of tiny particles (droplets) in the air.

Annual plant

A plant that germinates from seed, flowers, produces seed, and dies in the same year. It has a one-year life cycle.

Application rate	The amount of pesticide product or active ingredient applied to control a pest. It is often expressed as amount per area (e.g., 30 ml per $10m^2$), per length of crop row (e.g., 40 g per 10 m length of row) or as a dilution (e.g., mix 50 ml in 4 L of water and spray to thoroughly wet foliage).
Bacteria	One-celled microorganisms. Some cause disease in plants, insects or animals. They can only be seen with a microscope. Singular = bacterium
Basal treatment	An application of a pesticide to stems of plants from the ground to a short distance up the stem.
Behavioural control	Use of a pest's natural behaviour to help suppress population.
Beneficial	Useful or helpful to people (i.e. beneficial insect that feeds on aphids).
Biological control	The use of beneficial species to suppress populations of pests. These include predatory and parasitic insects, birds, nematodes, or disease organisms.
Broadcast application	An even application of pesticide over a whole area.
Broadleaf plant	An annual or perennial plant, shrub or tree with wide leaves. It differs from grasses, conifers and plants with needles or grass-like leaves.

Broad-spectrum pesticide	A pesticide that will kill, or affect, a range of organisms as well as the target pests. This is **not** a selective pesticide.
Buffer zone	Areas or strips of land left untreated to protect a nearby area (e.g. a sensitive water body, habitation).
Calibrate	1. To determine the amount of pesticide being applied through a sprayer nozzle, duster or granular applicator over a given area. 2. To mark a container or tank to indicate volume at certain levels.
Calibrated sprayer application rate	The amount of spray mix applied per unit area. This is determined from calibration procedure in field conditions (L/ha).
Calibration	Checking and adjusting the delivery rate of a pesticide by application equipment.
Carrier	Material that is added to a pesticide product to dilute it. It can then be evenly applied. This is often water.
Cartridge	The part of a respirator that absorbs fumes and vapours from the air before it is breathed in.
Cartridge filter (in a respirator mask)	A metal or plastic container filled with absorbent materials. This filters fumes and vapours out of the air before being breathed by the wearer.

Caterpillar	The larval, or immature, stage of moths and butterflies. (Lepidoptera).
Caustic	A corrosive chemical that may burn the skin.
Chemical degradation	The breakdown of pesticides by chemical reactions with other materials in the soil (e.g. water).
Chemical name	The name of the chemical structure of the active ingredient.
Chronic toxicity	Illnesses, disease, or adverse health effects that occur and persist over time after exposure(s). Chronic effects are often permanent. These may result from a single or repeated exposure to a pesticide.
Coleoptile	The first leaf of a grassy plant.
Commercial class (Agricultural or Industrial) pesticide	A pesticide meant for use in commercial agriculture, forestry, or industry (not the general public). They have low to medium toxicity.
Concentrate	The opposite of dilute. Concentrated pesticide formulations need to be diluted, often with water, before use.
Contact pesticide	A compound that causes the death of an organism that comes in contact with it. The pesticide does not need to be eaten or inhaled by the organism for it to work.
Contaminate	When a chemical alters or renders a material or food unfit to use.

Cotyledons	The first, or seed leaves, of a broad leaf plant.
Deciduous plant	A plant that loses its leaves in the fall and has bare branches in winter.
Defoliation	The loss of leaves from trees, shrubs or other plants (e.g., caused by feeding from leaf-chewing pests or by injury from herbicides).
Degradation	A complex chemical is reduced into a less complex form. This may be the result of microbes, water, air, sunlight or other agents.
Diluent	A substance, often water, mixed with a pesticide to make the proper concentration for application.
Dilute	To weaken the strength of a mixture make it (less concentrated), for example, by adding more water to a pesticide mixture.
Domestic class pesticide	Intended for home use. They contain active ingredients with low toxicity. They are usually sold in smaller volume containers then commercial class pesticides.
Dormant/dormancy	The yearly halt of visible growth in plants or activity in animals. This is usually the winter season.
Drift	Movement of pesticide droplets or dust, by wind or air currents, from the target area. Drift is a major hazard of pesticide application.

Drift retardants/thickener	A substance used to increase droplet size of spray material and reduce particle drift.
Ecosystem	A community of organisms that interact with one another and their environment.
Emulsifiable concentrate	A liquid pesticide concentrate that is made with an emulsifier. This mixes well with water to make a spray.
Exoskeleton	Layers of tissues that form the skeleton on the exterior of insects and mites. In immature stages the exoskeleton is often thin and soft. In adults it is often very hard or leathery.
Exposure	When someone or something comes in contact with a substance through the skin, by mouth or by breathing.
Fatty acids	Organic (containing carbon and hydrogen) chemical acid that occurs naturally in waxes, fats and essential oils. It is a component of some low toxicity pesticides.
Formulation	A mixture of active ingredient(s) with carriers, spreaders or other materials. These improve the storing, mixing and/or application of a pesticide.

Fungi	(Singular: fungus) A group of organisms lacking chlorophyll (green colouring). They grow from microscopic spores. Many fungi cause plant diseases, such as rots, rusts, mildews and blights; some species of fungi attack wood or cause decay in buildings. Others cause disease in insects. Many are microscopic.
Fungicide	A pesticide used to control fungi.
Geotextile	Synthetic fabric used in landscapes as soil coverings to smother weeds or prevent them from germinating.
Granular pesticide	A pesticide mixed onto tiny beads of clay or other materials to make coarse particles. They are applied dry using a spreader, seeder or special applicator.
Grub	The larval stage of some beetles.
Habitat	An environment in which organisms live.
Hazard	The danger of exposure and toxicity of a pesticide.
Herbaceous plant	A plant with soft, non-woody stems.
Herbicide	A pesticide used to kill plants and control vegetation.

Honeydew Sticky liquid excreted by aphids as they feed on plants.

Host A living plant or animal that a pest depends on for survival.

Hypha Filament or strand of vegetative fungal growth. plural = hyphae

Incompatible When pesticides cannot be mixed or used together. When incompatible pesticides are mixed together, one or more may come out of the mixture. The effectiveness of one or more may be reduced. Injury to plants or animals may result.

Ingestion or Oral exposure The intake of a substance by mouth (accidental ingestion, suicide attempts, or eating of contaminated food).

Inhalation exposure The breathing in of airborne particles of a substance. Fine powders, spray droplets, vapours, or gases may be inhaled into the lungs.

Injury threshold The level at which pest numbers are high enough to cause unacceptable injury or damage.

Insecticide A pesticide used to kill or repel insects.

Insect An organism with a hard exterior skeleton. Adult insects have a body divided into three segments (head, thorax and abdomen), three pairs of legs, and 1-2 pairs of wings (if present) attached to the thorax..

Instar — Each stage between moults of an immature insect as it grows.

Integrated pest management (IPM) — A decision-making process based on preventing pest problems. All available information and treatment methods are considered in order to act in an economically and environmentally sound manner.

IPM — see: Integrated Pest Management.

Larva — (Plural: larvae) The immature, second life stage of an insect. A larva hatches from an egg. Most are wormlike, such as caterpillars, maggots and grubs. Many pest insects cause the most damage in the larval stage, particularly those that eat plants.

LC_{50}: (lethal concentration 50%) — The concentration (in parts per million) of a pesticide in the air or water needed to kill half of the test animals or organisms exposed to it.

LD_{50}: (lethal dose 50%) — The amount of substance (in mg of pesticide/kg of body weight) that will kill half of the test animals exposed to the pesticide.

Leaching — The movement of chemicals through soil in water.

Maggot — The larval stage of flies and midges (Order Diptera). Maggots are legless.

Material Safety Data Sheet (MSDS)	Legislated under Workplace Hazardous Materials Information System (WHMIS). Provides information on health hazards, personal safety, and environmental protection for hazardous products. MSDS is not a legal document. It may not be available for all pesticides.
Maximum Residue Limit (MRL)	The maximum amount of pesticide residue that may safely reside in food products.
Metamorphosis	The complete change in shape and form of an insect during development from the immature to the adult stage.
Microbe	Tiny organisms (e.g. bacteria, fungi, and viruses) usually unable to be seen without a microscope.
Microbial insecticide	A biological pesticide that contains microorganisms, such as bacteria, viruses or fungi. These attack insects.
Micro-organism	A living organism, including a fungus, virus, and bacterium that can only be seen with a microscope.
Mite	Minute animal having eight legs in the adult stage. Some species are harmful. Some are beneficial. Closely related to spiders.
Miticide	A pesticide used to kill or repel mites.

Mode of action	The way a pesticide works to kill pests. For example, a poison that works on contact or as a stomach poison.
Molluscicide	A pesticide used to control snails and slugs.
Mollusc	A soft-bodied animal, which usually, but not always lives in water and has a shell, such as a clam, oyster or mussel. Some (snails and slugs) live on land, and move by means of a single "foot." Slugs are molluscs with no shells.
Moult	The process of shedding a skin or, in the case of insects, shedding the exoskeleton, to allow continued growth.
Nematode	One of a group of elongated, cylindrical worms, also called a threadworm or an eel-worm. Some species attack roots or leaves of plants. Others are parasites on animals or insects.
Non-persistent pesticide	A pesticide that breaks down soon after application into non-toxic compounds. It is only effective for a few days before it breaks down.
Non-selective herbicide	A herbicide that affects all plants that it contacts.
Nozzle output	The volume of spray produced by each nozzle per minute.
Nozzle spacing	The spacing between two or more nozzles.

Ocular exposure

The intake of a substance through the eyes. Eyes absorb pesticides easily through their many blood vessels.

Parasite

An organism that lives in or on the body of another and obtains nourishment from it.

Particle drift

Pesticide droplets or particles that move away from the treatment site and remain in the air after application.

Perennial

A plant that has a life span of more than two years. The top may die back in winter or during a drought. The roots or rhizomes persist to resume growing when conditions improve.

Persistence

The ability of a pesticide to remain in the environment for a long time without changing.

Persistent pesticide

A pesticide that takes a long time to degrade into simple compounds after being released into the environment; particularly those applied to soil that last more that one growing season (see: Residual pesticide).

Personal protective equipment or clothing (PPE)

Clothes, materials, or devices that offer protection from pesticides. These are important when handling or applying toxic pesticides (e.g. gloves, apron, boots, coveralls, hat, respirator, splash apron, goggles, and face shield).

Pest

Any harmful, noxious, or troubling organism that may cause an undesirable effect. Pests include: fungi, bacteria, viruses, weeds, insects, mites, rodents, and birds. Wildlife (raccoons, wolves, deer) may be considered pests.

Pesticide

Designed to kill, control, repel, attract, or manage pests. Any product that claims to do this is a pesticide under the Pest Control Product Act (P.C.P. Act) and Regulations. Chemicals that regulate plant growth, defoliants, and plant desiccants are also considered to be pesticides.

Pesticide label

As defined in the P.C.P. Act: "Any legend, word, mark, symbol, or design applied or attached to, included in, belonging to, or accompanying any control product." A pesticide label is a legal document.

Pesticide rate

The amount of pesticide applied per unit of area (or per plant) during a given time. It is stated on the pesticide label (mL/ha, g/ha or ml/L).

Pesticide residue

A deposit that remains in or on a crop or other substance after the application of a pesticide.

Pesticide resistance

Occurs when a pest population is exposed to the same, or a similar, pesticide for a number of times. A few individuals may have a genetic difference that enables them to survive a pesticide application.

These reproduce and generate a new population that is resistant to the pesticide.

Phenology — The relation between climate and biological events (e.g. flowering or leafing out in plants, or emergence of an insect pest).

Pheromone — A chemical produced by insects to communicate to other insects. These are used as signals, alarms, or to attract mates.

Photo degradation — The breakdown of pesticides by sunlight into simpler compounds.

Phytotoxic — Poisonous or injurious to plants.

Post-emergence — The stage in a plant life cycle after seedlings emerge from the soil.

Power hose sprayer — A boomless sprayer that uses a power-driven pump to provide pressure to the hose (e.g. spray gun).

Predator — An organism that preys on another. A predator kills its prey to feed on it.

Pre-emergence — The stage in a plant life cycle before seedlings emerge from the soil.

Pupa — (Plural: pupae) The life stage between the larva and adult in insects that undergoes complete metamorphosis. It does not feed. A pupa is usually inactive.

Pyrethrins	The group of active ingredients found in chrysanthemum flowers. They are unstable when exposed to sunlight.
Pyrethroids	A synthetic compound made to resemble pyrethrins in chemical structure. They are more toxic to insects and more stable in sunlight than pyrethrins. They may last for a week or longer when applied.
Quantitative measurement	Information in terms of numbers, fractions or other quantities.
Random sampling	Collecting samples based on chance. This ensures that samples collected are likely to give a good, unbiased estimate of the situation.
Ready-to-use pesticide	Pre-mixed or pre-diluted pesticides. It may be used straight out of the container.
Recommended sprayer application rate	The amount of spray mix applied per unit of area (per unit of time) as stated on a pesticide label (e.g. L/ha).
Repellent	A compound that drives pests away from a treated object, area or individual.
Residual effect	The length of time a pesticide remains effective after it is applied.
Residual pesticide	A pesticide that continues to kill or repel for some time (e.g., weeks or months) after application.
Residue	An amount of pesticide that remains on or in the crop (or other substance).

Respiration Breathing. This is also the physical and chemical process by which an organism supplies cells and tissues with oxygen. It is the use of oxygen to produce energy to sustain life.

Respirator A device to protect the wearer from breathing hazardous air.

Restricted class pesticide A pesticide with safety concerns for humans, plants, animals, or the environment. They often have special detailed labels to show how to handle them safely.

Rhizome An underground plant stem that sends shoots above the soil surface and roots below it.

Risk The chance that someone or something will be harmed by the toxicity of a pesticide and one's exposure to it.

Rodenticide A pesticide used to control rodents (rats or mice).

Runoff Movement of water down a sloping surface.

Seed bank Seeds (mostly weed seeds) that have built up over the years in the top layer of soil.

Selective pesticide A material that destroys or repels a certain group(s) of organisms. For example, a selective herbicide may kill broadleaf weeds in a lawn without harming the grass.

Selectivity The tendency of a pesticide to harm (or not harm) a broad range of organisms.

Semiochemical A "message chemical" that is used by insects as a signal. Some are produced by plants to attract or repel insects. Others are produced by insects to cause alarm or attract mates.

Spot treatment A pesticide application to a small area (e.g., individual plants).

Spray drift The airborne movement of spray or particles from a treatment site during the application of a pesticide.

Spray width The actual width of spray.

Spreader A material added to a pesticide formulation that allows the pesticide to form a uniform coating over a treated surface.

Sterilant A non-selective chemical that kills all organisms. These stop the germination of seeds and the growth of plants, often for a long time after application.

Sticker A material added to a pesticide formulation that allows the pesticide to stay on the treated surface.

Stolon A horizontal branch or runner from the base of a plant. It produces new plants.

Strainer	A device for screening out solids while liquids pass through.
Surface runoff	Movement of pesticide from the spray area over the soil surface.
Surfactant	A substance used in a pesticide to make mixing easier. It reduces surface tension of a liquid to spread it out over a surface (rather than "beading-up" in small droplets). This allows it to adhere to the surface being treated. Examples include: emulsifiers, soaps, wetting agents, detergents and spreader-stickers.
Systemic pesticide	A pesticide that is absorbed into the plant and moves through the plant tissues; e.g., a systemic insecticide may move through a plant to kill sucking insects.
Tank mix	The blending of pesticides in the same spray tank. Pesticides should not be "tank mixed" unless approved on the label of each pesticide to be mixed.
Thatch	A layer of dead plant material on lawns at the base of grass leaves. A certain amount helps to protect roots from heat, cold and drought. A thick layer smothers roots and blocks fertilizer and water from reaching the soil.
Tiller	A secondary shoot of a grass plant.
Toxic	Able to poison a living organism; poisonous.

Toxicity — The harm a particular pesticide may cause to an organism. Toxic effects may vary with sex, health, age, weight, or prior exposure to other pesticides.

Travel speed — The speed that application equipment is driven or walked (with a hand held sprayer).

Vapour — Gas produced by a substance that is solid or liquid at room temperature. A gas or vapour is not an aerosol or mist (composed of tiny droplets of liquid suspended in air).

Vapour drift — Movement of vapours (fumigant or volatile pesticide) from the area of application. It usually occurs after an application.

Virus — A protein body that may infect and multiply within a host plant or animal. It often causes disease.

Volume of spray mix — The total volume (litres) of pesticide(s), diluent, (e.g. water), and other additives such as adjuvants. This is prepared in the spray tank for application.

Wettable powder — A powder with a wetting agent. This allows it to be readily mixed into water to form a suspension.

WHMIS — Workplace Hazardous Materials Information System.