Unit 4. Application Systems and Equipment

Learning Objectives

After studying this unit, you will be able to:

• Compare and contrast the three main types of irrigation systems.
• Decide which type of irrigation system is best for your needs.
• Name and describe the different types of equipment needed for chemigation.
• Know what antipollution devices are required for chemigation.
• Understand the basic management principles necessary for successful chemigation.

The heart of any chemigation operation is its equipment. For a successful chemigation, you must first choose which irrigation system is best for your needs: sprinkler, drip/trickle, or surface/gravity flow. You must then have the system properly designed and installed. This unit will discuss the three main types of irrigation systems. It will also describe the different types of sprinkler systems.

You will learn important details about the equipment that makes up a chemigation system. This includes tanks, pumps, calibration tubes, and antipollution devices. Just as important, this unit will teach you some vital do's and don'ts for successful chemigation. These management tips will help you prevent problems and avoid common pitfalls.
Terms to Know

Agitation—The process of stirring or mixing. Some pesticide formulations (such as wettable powders) require constant agitation to be effective and to ensure even distribution.

Dilution Ratio—A specified proportion of pesticide to water (ex. 1:100).

Drip/Trickle Irrigation (Microirrigation)—An irrigation method in which water is applied through drip emitters with very low flow rates using flexible hose or tape.

Emitter—An opening, or orifice, on a drip irrigation system through which water emerges.

Flood Irrigation—A surface irrigation method in which water is applied to the soil without flow controls such as furrows or borders.

Furrow Irrigation—A surface irrigation method in which water flows through small ditches or furrows that guide the water across the field.

Precipitate—An insoluble solid substance, or deposit, that forms on water-emitting devices.

Proportional Rate Injection System Device that delivers pesticide into the waterline in a way that maintains a constant proportion of pesticide to the water flow rate.

Sprinkler Irrigation—An irrigation method in which water is sprayed or sprinkled through the air to the ground.

Surface/Gravity-Flow Irrigation Irrigation methods consisting of flood and furrow techniques.

Traveling Gun—A large, single-impact sprinkler that moves across the field on a wheeled cart connected by a hose to a reel. As the hose is reeled in, a swath is irrigated.

Venturi—An injector device that operates on a pressure differential between the inlet and outlet of the injector. It creates a vacuum, which results in suction or a “venturi” effect.
The three basic types of irrigation systems are:

- sprinkler,
- drip/trickle (microirrigation), and
- surface/gravity flow.

Sprinkler systems are often used for irrigation, and some are well suited for chemigation. Many drip systems are also effective in applying fertilizers and pesticides. Surface/gravity-flow irrigation methods are not commonly used in Virginia and are less appropriate for chemigation.

**Sprinkler Systems**

There are many types of sprinkler systems used for chemigation. These include:

- center pivot,
- self-propelled linear or lateral move,
- solid set,
- hand-move lateral,
- side-roll lateral, and
- towline lateral.

The traveling (big) gun is not suitable for chemigation and is mainly used for pasture irrigation.

Of these sprinkler systems, the center pivot and self-propelled linear move systems are best suited for chemigation. This is because they tend to give a more uniform application. Linear systems provide the most consistent application.

**Center Pivot**

Center pivot sprinkler systems are very popular for chemigation. Well-designed and -operated center pivots give good uniformity in water and chemical application. The key to good uniformity is to select the right sprinkler package for your field and configure the equipment with care to limit drift and runoff.

One way to control runoff is to apply the minimum amount of irrigation water when your system is running at its maximum speed. A practical minimum application rate for a typical center pivot system is about 0.1 inch. This works out to about 2,700 gallons per acre. See Unit 3 (Safety Considerations) for more information about controlling surface runoff with center pivot sprinklers.

As discussed in Unit 3 (Safety Considerations), end guns and corner systems are often used with center pivot irrigation systems. Using either system, however, can lead to problems with uniform application. This lack of uniformity is due to variations in system pressure and distribution pattern. In general, the use of end guns and corner systems during chemigation is NOT recommended.

**Self-Propelled Linear or Lateral Move**

Self-propelled linear systems, like the center pivot, can apply both water and pesticide very uniformly. For a given pumping rate, these systems will apply less water as their speed increases. They move laterally across a field instead of in a circle.

Self-propelled systems have two advantages:

- they can irrigate an entire rectangular field, and
- they can be configured as either high- or low-pressure systems.

However, they are also very expensive.

**Stationary Systems**

Stationary sprinkler systems (ex. solid set) do not move during the application. They are set on different areas of the field and remain in place during the treatment. This often means that fields must be treated over several sets.

In this way, they are unlike the center pivot and self-propelled linear systems. Their biggest problem is wind distortion of the sprinkler pattern.

Another problem with these systems is the risk of chemical exposure when moving them from one application site to the next. Stationary systems, however, may give more uniform application because the treatment is made in blocks.
Traveling Gun

The traveling gun—also called traveling big gun or hose drag traveler—can give extra mobility. These systems can easily be moved from one field to another. However, traveling guns apply water and pesticide much less uniformly. Like the stationary systems, they are prone to wind distortion.

The hose and volume gun equipment also may increase workers’ risk of chemical exposure.

A traveling gun system works best when there is little wind. However, it is likely to give poor uniformity even under the best conditions. In addition, higher application rates may sharply increase the risk of runoff. All these drawbacks make traveling guns a poor choice for chemigation. Their main use is to irrigate pastureland.

Drip/Trickle (Microirrigation) Systems

Drip or trickle irrigation is the frequent, low-volume application of water to soils. The water (and pesticide) passes through emitters, orifices, or porous tubing. Most drip systems apply water to the soil surface or within the root zone. Some may be installed below the surface. This reduces soil evaporation and encourages root growth in a limited area. Drip systems are not suitable for broadcast or foliar applications. They work best with fertilizers, soil amendments, and herbicides that must be applied to the soil surface (laterals) or incorporated to a certain depth below the surface (subsurface drip systems).

Emitters

Emitters are openings through which the water/pesticide mixture emerges. Most emitters lie on the ground. However, you can also suspend them above ground or bury them. The latter is common with drip tape.

NOTE: If you choose to place emitters underground, you should first notify the Environmental Protection Agency (EPA) as part of the underground injection control (UIC) program.

Although some emitters can apply water to a larger area using a spray nozzle style, most systems cannot apply water uniformly to the entire crop canopy.

Types of Emitters

There are many different types of emitters. They include:

- point source emitters,
- line emitters,
- microsprays or sprinklers, and
- porous hose/double wall emitters.

Point source emitters, or “drippers,” usually deliver about 1 to 2 gallons per hour at each point. Line emitters, which are perforated tubes, deliver 0.15 to 2 gallons per hour per foot of length. Microsprays, or “jets,” have higher discharge rates. They spread the water over a much larger area, which reduces the application per square foot of soil surface. Finally, porous hose/double wall emitters are in-row, full-length watering devices. These devices, however, give poor uniformity and are not recommended for chemigation.

Surface/Gravity-Flow Systems

In general, surface or gravity-flow (furrow and flood) irrigation systems are of limited use in chemigation. This is true for the following reasons:

- Water distribution is typically non-uniform along the row.
- These systems cannot be used for foliar applications.
- Many pesticide labels do not allow furrow or flood applications.
• Surface systems may not wet the soil enough on ridge tops of hill- or bed-planted crops.
• The wetting pattern may concentrate the product on ridge tops or hills.
• The chemical(s) may not be distributed evenly along the length of the furrow if the water flows too slowly.

Furrow Irrigation

In furrow irrigation, small ditches or furrows guide the water across the field. Forming the furrow, or bed, is crucial because it influences:
• rate of flow,
• amount of water applied, and
• uniformity of the application.

Furrow-slicking devices and bed-forming machines produce a smooth, firm, clod-free surface that helps the water flow more freely during the first irrigation.

Flood Irrigation

In flood irrigation, you apply water to the soil without flow controls such as furrows or borders. For the first irrigation, you will need a water application of at least 2 to 2-1/2 inches. You will also need a reuse pit to collect tailwater. Collect and apply tailwater on the same field or on other crops for which the chemical is labeled. See Unit 3 (Safety Considerations) for more information about tailwater control.

Surge-Flow Irrigation

Surge valves, or surge-flow irrigation, may help you get a more uniform water application with surface irrigation systems. They also reduce deep seepage and runoff by pulsating flows across a field. With experience, you can program surge valves to apply water and pesticides uniformly when field conditions are good. The pesticide label will tell you whether the product may be applied through a surge-flow system.

Chemigation Equipment

Before you can apply chemicals through an irrigation system, you will need some basic equipment. Some of this equipment the antipollution devices - is required by law. Make certain that your equipment is compatible with the products that you will apply through the system. Every chemigation system needs:
• a pesticide supply tank with agitator,
• an injection pump or device,
• a calibration tube, and
• safety devices to protect the water source.

If you are chemigating in a greenhouse, you may also need a proportional rate injection pump.

Pesticide Supply Tanks

Choose a pesticide supply tank made of noncorrodible materials. The best choices are stainless steel, fiberglass, or polyethylene plastic. Avoid tanks made of iron, copper, aluminum, or brass. They are more likely to rust, corrode, or produce toxic fumes: Certain formulations need constant agitation, either hydraulic or mechanical. Check the label for instructions. It will state whether you must place the product in a certain type of tank. The product label, in addition, will include a warning of any problems with chemical incompatibility.

Some pesticides are flammable. Again, check the label to see if your product is flammable and, if so, what precautions you must take. These may include:
• using explosion-proof electric motors and wiring,
• keeping a separation distance (so that a spark of electricity cannot cause an explosion), and
• diluting the chemical.

Make sure all wiring meets the requirements listed in the National Electrical Code for hazardous area applications.
Other Factors

Your pesticide supply tank should keep all windborne foreign materials out. These include dirt, leaves, crop residue, and rainwater. It also should be completely drainable with a sump at the drain port for ease in rinsing. Put accurate, easily readable gallon marks on the outside of the tank.

If you also fertigate, you may need more than one type of tank. For example, you may need a larger-capacity tank for fertilizers and a smaller one for pesticides.

If you store pesticides in a tank, federal law requires you to:

- display the maximum quantity of the tank,
- attach a complete pesticide label,
- make sure the tank is structurally sound, and
- secure the tank by tightly closing the lid.

Virginia law requires you to label concentrate service containers (tanks) of all types and sizes. The labeling must indicate whether the product to be stored or transported will be diluted or applied as an end-use concentrate.

Be sure your pesticide supply tank has a manually operated valve. This valve allows you to close the chemical supply line in case of equipment failure or shutdown.

Injection Pumps and Devices

The chemical injection pump is the heart of your chemigation system. Ideally, the pump should have a delivery accuracy of ± 1% within its operating range. In practice, however, changes in temperature and other factors may cause your pumping rates to vary.

The pump should be easy to adjust for different injection rates and be mechanically sound. Make sure all of its components are made of noncorroding materials. In addition, be sure to clean your pump after each use. Any remaining pesticide within a pump can shorten the pump’s life and cause seals or hoses to fail.

Capacity and Output Rates

Make sure the capacity rate of your pump matches the application rates of the chemical(s) you plan to use. No one pump can do all jobs. Chemical application rates vary widely. You may need a pump injection rate as low as 2 gallons per hour or as high as 400 gallons per hour. Most pumps are graduated in units or percentages. These may indicate the amount of liquid pumped at a certain setting. These settings, however, are not exact. You will need to verify all settings and values by calibration. See Unit 6 (Calibration) for more information on calibration procedures.

Do not operate a pump at either its maximum or its minimum output. You could damage the pump or produce incorrect pumping rates. Piston pumps are especially easy to damage in this way. They tend to lose their suction power as you reduce the stroke length of the piston. It is best to run the pump in the middle of its output range.

Positive Displacement Type

Some pesticides labeled for chemigation may require the use of a positive displacement pump. This type of pump has three main features:

1. Its output cannot be easily throttled.
2. Each pump stroke injects a given volume.
3. It gives a high volume output.

Diaphragm and piston pumps are examples of positive displacement pumps.

Diaphragm

Diaphragm pumps have a membrane, or diaphragm, separating the drive mechanism from the pesticide. Both single- and dualport pumps are available. It is important to choose the right diaphragm. This will eliminate leakage problems that are more common with piston pumps.

Many researchers and experts agree that diaphragm pumps are the best all-around pumps for injecting pesticides into irrigation. Chemigators have used them since the mid-1980s. Although they
are usually more expensive than either piston or venturitypes, diaphragm pumps have several benefits:

- They have only a few moving parts and are dependable.
- A very small part of the pump is exposed to the pesticide. This cuts down on corrosion, wear, and leakage. It also reduces maintenance costs as well as the chance of pesticide exposure.
- It is easy to adjust the injection rate while the pump is operating. For most diaphragm pumps, just turn a micrometer type adjustment knob.

However, the discharge flow rate of many diaphragm pumps may suffer if there are changes in irrigation mainline pressure. These changes may cause the discharge pressure of the pumps to vary a great deal.

NOTE: Select the diaphragm material in accordance with the chemicals being pumped.

**Piston**

Piston pumps were the first pumps available for chemigation. They come as both single- and dual-piston units with a wide range of capacities. Their main advantage is their relatively high capacity. They are mostly used to apply fertilizers at high injection rates.

Piston pumps have two big drawbacks:

- Their seals wear rapidly with abrasive materials, which can cause leaks. This increases maintenance costs and the chance of pesticide exposure.
- Calibration is often time-consuming. To change the injection rate, you have to stop the pump and adjust the stroke length mechanically. Then, you must restart the pump and check the new injection rate. Some newer pumps, however, allow adjustment during operation.

Like the diaphragm pump, discharge flow rate of piston pumps will change as the irrigation pipeline pressure varies.

**Proportional Rate (Differential Pressure) Type**

Some injection devices use a different system: proportional rate (differential pressure).

A proportional rate injection system meters chemicals into an irrigation waterline. It is used mostly to apply fertilizers. However, you can also use this system to apply pesticides. Proportional control is activated by a feedback system that monitors the flow rate of the irrigation pipeline. It then varies the injection rate accordingly.

Proportional rate injection devices do not work in the same way as the injection pumps described above. Those pumps (diaphragm and piston) deliver a calibrated amount of pesticide per unit time (ex. 2 gallons per hour). Proportional rate devices, however, deliver pesticide into the waterline in a way that maintains a constant proportion of pesticide to the water flow rate. This proportion is called the “dilution ratio.” For example, suppose you set your proportional device at a dilution ratio of 1:100. This means it will deliver 1 part (ex. quart) of pesticide into every 99 parts (ex. quarts) of water. This also means that the rate of injection (ex. gallons per hour) will vary with the water flow rate.

There are several different types of proportional rate injection systems. They include:

- venturi type,
- displacement diluters,
- positive displacement pump, and
- EC-controlled injection units.

Each has its benefits and drawbacks.

**Venturi Type**

Venturi units generate a differential pressure, or zone of low pressure, across a venturi device. This means they use a difference between the inlet and outlet pressure of the injector to add chemical(s) into the irrigation water. This creates a reduced-pressure zone, which draws the pesti-
cide out of the pesticide supply tank and into the bypass line. The differential pressure is controlled by either:

- a pressure-reducing valve installed in the main line of the irrigation system, or
- a small auxiliary (centrifugal) pump that works with the venturi device.

Venturi meters are mainly used in drip irrigation systems. They are most common in vegetable production, greenhouses, university research plots, and tree fruit production. Their benefits include relatively low cost and simplicity. They are also easy to calibrate if they are used with an in-line flow meter. Venturi units are sometimes called positive pressure pesticide application systems.

Venturi-type proportional rate devices use pressure differences to draw pesticide into the water stream. If the pipeline pressure is constant, injection rates will be accurate. Their dilution ratio is usually low, around 1:15. Thus, they are most useful for small jobs. You can adjust the amount of pesticide that enters the water stream by changing the orifice size or the water pressure.

NOTE. Venturi systems must maintain a minimum difference in pressure (pressure differential) to produce the suction needed.

**Displacement Diluters**

Displacement diluters are similar to venturi-type devices. They have no moving parts, and the pesticide concentrate goes into a container. Some water from the waterline enters the container and displaces an equal volume of pesticide, which enters the waterline through a separate opening. The incoming water does not mix with the pesticide because of the density differences between the liquids. The rate of dilution for displacement diluters is greater than that for venturi units. However, the dilution ratio still depends on the flow rate and pressure of the water supply.

**Positive Displacement Pump**

A positive displacement pump injects a fixed amount of pesticide into the waterline. These pumps are either hydraulic (water powered) or electric. With hydraulic pump proportional rate devices, a flow of water powers a piston pump that injects a fixed amount of pesticide into the waterline with each stroke. With electrically driven devices, a rotary piston-type water meter monitors the flow of water. Again, a fixed amount of pesticide flows into the water stream with each stroke.

**EC-Controlled Injection Units**

EC injection units monitor the electrical conductivity, or in-line flow, of the pesticide in the waterline. This varies the operating speed of the pump. A proportional rate injection device or pump injects pesticide into the line whenever the conductivity falls below a certain level.

**Calibration Tubes**

A calibration tube should go in the line between the pesticide supply tank and the injection pump. Use it to measure the output of the injection unit when you calibrate and during the actual chemigation. The capacity of your injection system will affect the size of calibration tube you need. Make sure your calibration tube is:

- clear (transparent),
- breakage resistant,
- ultraviolet (UV) resistant, and
- graduated in units of volume (pints, ounces, or milliliters).

To properly calibrate an injection system, you should monitor the pesticide injection for at least 5 minutes. This means the calibration tube must be large enough to hold the pesticide that will accumulate during that time.

You do not have to permanently attach the calibration tube to the injection system. However, you need to be able to attach it to the suction line quickly and easily while the pump is running. This allows you to check the injection rate from time to time.

For more information on calibration procedures, see Unit 6 (Calibration).
Antipollution Devices

Antipollution (safety) devices reduce hazards to the environment in case of equipment failure during chemigation. Your irrigation system must ensure that any interruption of water or pesticide flow automatically prevents backflow into the water supply.

Safety devices are required by law. See Unit 1 (Introduction) for more information on laws governing chemigation and backflow prevention. These laws aim to prevent water pollution as it might occur in many ways. Without properly functioning safety equipment in place, failure of the irrigation equipment could have these results:

- The pesticide mixture could flow from the pesticide supply tank back to the water supply if pressure in the irrigation main line is lost. If the water supply is the drinking water supply, this will result in exposure of water consumers to Chemigation chemicals possibly resulting in serious injury or death. If the water source is an irrigation source, this may result in either groundwater or surface water contamination requiring expensive cleanup.

- The injection pump could shut off while the irrigation pump continues to run. This could cause the water to flow back through the injection system and flood the supply tank. This could result in a spill of chemicals at the tank site causing environmental contamination and damage and human exposure to full strength chemicals requiring potentially expensive cleanup and potentially serious illness to people living and working nearby and to cleanup workers.

- If both the injection pump and the irrigation pump shut down, the pesticide mixture in the irrigation pipeline could be siphoned back into the water supply. This would result in the environmental and public health damage described in the water supply contamination above.

- If the irrigation pump shuts down and the injection pump continues to run, undiluted pesticide could be injected into the irrigation line. This could pollute the water supply or load the irrigation line with pesticides. The undiluted pesticides, in turn, might later flow onto the field at a high rate. In the first case, this would result in the same environmental and public health damage described as a result of water supply contamination above. In the second case (undiluted pesticides), this would cause damage to crops, or render the crops unusable and possibly hazardous waste due to heavy chemical exposure.

Procedures and Equipment

To protect the water supply, start by choosing the right chemigation equipment. Your equipment should resist chemical corrosion and stand up to the weather. It should also be the right size for the job. Then, inspect and maintain all equipment to make sure that it is working properly. Finally, manage your chemigation system for safe and effective chemical application.

Required safety devices may include the following:

- Reduced pressure principle backflow preventer (also called reduced-pressure backflow assembly [RPBA] or reduced-pressure zone valve [RPZ]) if connected to a public water source or approved air gap if irrigation system is receiving water from public water source.

- Reduced pressure principle backflow preventer, RPBA or RPZ located before the injection point if chemigation is taking place on an irrigation system to protect the rest of the irrigation system as well as the irrigation system source.

- Irrigation mainline check valve.
- Vacuum relief valve.
- Low-pressure drain.
- Pump interlock.
- Flow interrupter (normally closed solenoid valve) or quick-acting, spring-loaded check valve on the chemigation injection line.
- Injection-line check valve.
- Inspection port.

These and other safety devices are discussed in more detail in Unit 5 (Backflow Prevention).
Management Principles

Good management is vital to the success and safety of chemigation. Any time you apply a chemical through an irrigation system, you must take certain steps before and after the application. Most chemigation-related accidents result from:

- careless practices,
- poor choice of equipment,
- lack of knowledge on how to handle chemicals safely,
- lack of monitoring, or
- poor system maintenance.

Pesticide injection pump safety interlock.

Injection system (including the in-line strainer and injection-line hoses).

Water supply pump and water source.

Injection pump or device.

Taking safety precautions is an investment in the health and safety of the environment, other people, and you. It also helps you get good results. See Unit 3 (Safety Considerations) for more information on environmental protection and personal safety.

Read the Label

Before you start to chemigate, ALWAYS read the product label and comply with all directions and restrictions. The label will state whether you may apply the product through an irrigation system and, if so, which type of system. It will give you specific directions on application rates, the crops you can treat, and any protective equipment you may need. In addition, it will give details on restricted-entry intervals, worker notification and posting requirements, and antipollution devices. The label may also tell you how to dispose of empty pesticide containers. Be sure to read all the sections of the pesticide label before you buy the product and again before you chemigate. See Unit 1 (Introduction) for more information on labels and label requirements.

Inspection, Maintenance, and Repair

Keep your chemigation equipment in good working order. Regularly inspect all hoses, clamps, and fittings and replace them as needed. Also, inspect pumps, tanks, and electrical devices. Before you chemigate, conduct a site assessment and check the following to be sure they are working properly:

- Irrigation mainline check valve, vacuum relief valve, and low-pressure drain.
- Pesticide injection-line check valve.
- Irrigation system and pumping plant main control panel.

Pay special attention to all equipment parts that will contact chemicals. These parts—from the supply tank to the point of injection on the irrigation pipeline—should be made of chemically resistant materials. In addition, heat, sunlight, and pressure may degrade the injection tubing. Some manufacturers recommend replacing injection-line hoses each year.

Monitoring

During chemigation, check the irrigation system and pesticide injection equipment to make sure they are operating correctly. To do this, you must keep the area around the main control panel, water pump, supply tank, and injection pump free from chemical contamination. One way to do this with a center pivot system is to plug the nozzle outlets near the equipment.

Plugging First Nozzles on Center Pivots

Plug the nozzle outlets near your equipment. This procedure is called plugging first nozzles on center pivots. It will greatly reduce the chance of chemical pollution and will allow you to monitor more effectively.
Flushing

You should flush your injection and irrigation systems by running water through them each time you chemigate. Flush the tank and the injection equipment as well as the distribution and application systems.

Injection System

Flush the injection system with clean water after each use. This will keep precipitates (deposits) from forming. It will also help prevent product incompatibility by removing all traces of the pesticide. You should flush your injection system while the irrigation system is still running. This allows you to apply rinse water to the treated site. Pump water through the system for at least the flush or fill time of the system.

Irrigation System

After injection is complete, run the irrigation pump for at least 15 minutes—or the fill time—whichever is longer. Drip systems may take longer to completely flush. If the irrigation system shut itself down automatically, flush the system as soon as you discover the shutdown. Extend the flushing period to at least 30 minutes as a precaution against backflow.

Avoiding Clogging

Clogging is a common problem in drip irrigation. Follow these guidelines to avoid clogging:

- Place the chemical injection point upstream of the filter. This will allow the filtration system to remove any precipitates that might otherwise clog the drip system.
- Inject sanitizing agents such as sodium hypochlorite or sulfuric acid to control precipitates.

Troubleshooting

Good management often means preventing a problem before it starts. If you regularly inspect and monitor your equipment, you can protect both your investment and the environment. Here is a list of do’s and don’ts to help you practice good management when using pesticides. It applies to all pesticide application, not just chemigation.

- Use pesticides that are soluble in water. Or, choose a pesticide that can be mixed or suspended uniformly in and carried by water.
- Before you combine chemicals in a tank mix or stock solution, check the label to make sure they are compatible. Then, conduct a compatibility test. For example, you could mix a small amount of the chemicals in a jar and observe the results. Water sources and contents vary widely. Check:
  - pesticide-to-water compatibility, and
  - pesticide-to-pesticide compatibility.
- Use pesticides that will not harm your system components.
Table 4-1. Management practices for optimal use of pesticides

<table>
<thead>
<tr>
<th>DO</th>
<th>DON’T</th>
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<tbody>
<tr>
<td>Do learn about the pests and controls.</td>
<td>Don’t compulsively use a chemical without looking for the best control method.</td>
</tr>
<tr>
<td>Do reduce excessive treatment.</td>
<td>Don’t think that more chemical will provide better control - it won’t. It may be less effective or may even cause environmental problems such as leaching or harm to wildlife.</td>
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<tr>
<td>Do read labeling.</td>
<td>Don’t assume a set application rate is universal. Variations among crops and soils make a difference when using pesticides. Also, labels, formulations, and requirements often change.</td>
</tr>
<tr>
<td>Do optimize application timing.</td>
<td>Don’t just spray. The time of day or year can influence pesticide effectiveness. Remember to check the label for tips on individual chemicals.</td>
</tr>
<tr>
<td>Do rotate crops and farming practices.</td>
<td>Don’t plant the same crop in the same location year after year, if possible. Rotation reduces disease, insects, and weeds while enhancing pesticide effectiveness.</td>
</tr>
<tr>
<td>Do identify high-risk areas.</td>
<td>Don’t assume that you should apply the same rate of chemical to all areas. Some areas should be safeguarded from any pesticide use if groundwater contamination or other environmental hazards exist.</td>
</tr>
<tr>
<td>Do use pesticides only when needed.</td>
<td>Don’t just spray. Save yourself some time and money by using a pest management system where applications are made only after scouting. If the damage seen when scouting verifies that pesticides are needed, consider using chemical control.</td>
</tr>
<tr>
<td>Do use appropriate safety measures with your equipment</td>
<td>Don’t assume that all sprayers are alike. Correct calibration and safety devices must be tested before spraying.</td>
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<tr>
<td>Do use alternative pesticides.</td>
<td>Don’t use products in the same chemical family year after year. This encourages pest resistance and buildup of residue levels. Choose an alternative, if available.</td>
</tr>
<tr>
<td>Do use integrated pest management.</td>
<td>Don’t just spray. An integrated management program will allow pesticide used wisely to be more effective and may curtail pest resistance to chemicals.</td>
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<tr>
<td>Do optimize pesticide placement.</td>
<td>Don’t spray where the chemical won’t be effective.</td>
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Table 4-1. Management practices for optimal use of pesticides (continued)

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<thead>
<tr>
<th><strong>DO</strong></th>
<th><strong>DON’T</strong></th>
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<tbody>
<tr>
<td>Do use biological controls.</td>
<td>Don’t just spray. If effective, biological controls can save you the money you normally use on pesticides. This program may be better.</td>
</tr>
<tr>
<td>Do consider cultivation.</td>
<td>Don’t just spray. Cultivation for part or all the weed control in the field may be more economical.</td>
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<tr>
<td>Do use lowest effective pesticide rates.</td>
<td>Don’t just apply the maximum rate. Some areas may be able to use less pesticide for effective control of pests.</td>
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<tr>
<td>Do use resistant crop varieties.</td>
<td>Don’t rely on pesticides alone. Save yourself some time and expense by preplanning your pest management strategy.</td>
</tr>
<tr>
<td>Do consider terrain, water sources, and other sites that require specific application techniques.</td>
<td>Don’t assume all areas can be aerially sprayed, power sprayed, or hand sprayed. Specific geological areas where pesticide contamination can occur or where neighbors may receive drift may require special attention.</td>
</tr>
<tr>
<td>Do optimize crop planting time.</td>
<td>Don’t rely on pesticides alone. Planting a crop at the right time may allow the crop to outcompete less seasonable weeds.</td>
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<tr>
<td>Do optimize pesticide formulation.</td>
<td>Don’t just spray. Using spreaders, stickers, or other adjuvants may optimize the pesticide’s usefulness, allowing you to use less chemical for an effective job of control.</td>
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