

Unit D: Agricultural Equipment Systems

Lesson 5: Operating, Calibrating, and Maintaining Spraying Systems

Student Learning Objectives:

Instruction in this lesson should result in students achieving the following objectives:

1. Identify the types of sprayers.
2. Describe the selection of sprayers and their components.
3. Explain the operation of a sprayer.
4. Describe the calibration of sprayers.
5. Identify how sprayers are maintained.

Recommended Teaching Time: 2 hours

Recommended Resources: The following resources may be useful in teaching this lesson:

Kiess, Aaron. *Chemical Application Management*. Moline, Illinois: Deere & Company, 1994.

List of Equipment, Tools, Supplies, and Facilities:

- Writing surface
- PowerPoint Projector
- PowerPoint Slides
- Transparency Masters
- Copies of student worksheets
- Personal protective equipment
- Examples of sprayers

Terms: The following terms are presented in this lesson (shown in bold italics and on PowerPoint Slide 2):

- Air sparging
- Atomization
- Control valves
- Nozzles
- Pressure gauge
- Pump
- Relief valve
- Screens
- Strainers

Interest Approach:

Have a student come to class wearing personal protective equipment and carrying a hand sprayer. Lead a discussion concerning pesticides, their application and safety associated with them.

SUMMARY OF CONTENT AND TEACHING STRATEGIES

Objective 1: Identify the types of sprayers.

Anticipated Problem: What are the types of sprayers?

(PowerPoint Slide 3)

- I. Most pesticides are applied with sprayers. There are many variations and combinations of sprayer types. Each sprayer has guidelines for its proper use and for the use of the pesticide to be applied. Most liquid-pesticide application equipment falls into the following categories:

(PowerPoint Slide 4)

- A. Hand-operated sprayers operate in the 35 to 275 kPa range and are commonly used by home gardeners and others whose pest problems are relatively small. Compressed-air sprayers with a capacity from 4-20 liters are simple in design, easy to operate, and relatively inexpensive to buy and maintain. Pressure is provided by a hand operated air pump which fits into the tops of the tank. Air compressed in the tank above the spray material forces the liquid out of the tank through a tube. A valve at the end of a short length of hose controls the flow of liquid. Agitation is provided by shaking the tank.
- B. Knapsack or back-pack sprayers have a small piston or diaphragm pump that is powered by the operator or by a small gasoline engine.

(PowerPoint Slide 5)

- C. Low-pressure sprayers are the most widely used type of field application equipment. They are usually operated in the 140 to 350 kPa range and apply from 20-230 liters per hectare.
 1. They are relatively inexpensive and are adapted to many uses including pre- or post-emergence application of chemicals to control weeds, insects, and diseases.
 2. Low pressure sprayers are available in many models and types and may be mounted on tractors, trucks, trailers, and aircraft.
- D. Controlled droplet applicators apply low volumes of pesticide mixtures.
 1. Typical volume is 3.5 to 11 liters of spray mix per hectare and are most often used with foliar applied herbicides.
 2. Instead of nozzles, they use a spinning disc or cup with serrated edges onto which pesticides drop. Cups or discs, powered by electric or hydraulic motors, spin at speeds of 1000 to 6000 rpm, producing small droplets that are relatively uniform in size.

(PowerPoint Slide 6)

- E. High-pressure sprayers are similar to low-pressure sprayers, with the exception that they are capable of higher working pressure of up to 6900 kPa.
 - 1. High pressure is used to force spray through dense foliage or to the tops of tall trees.
 - 2. They range from models that have a single nozzle on a handgun to large units with multiple nozzles that are mounted on a boom.
 - 3. High pressure sprayers are built strong to withstand extreme pressure and are more expensive than conventional low-pressure models.
- F. Air-carrier sprayers or air-blast sprayers are often called mist blowers.
 - 1. A high-speed air stream carries pesticides to the surface being treated.
 - 2. Sprayers are rated in air capacity and velocity. Capacities range from 1,500 to 18,000 cubic meters per minute and air speeds range from 130 to 250 kilometers per hour.
 - 3. Since air carries the pesticide to the target, little dilution with water is needed and less time is required for filling the sprayer. This results in a more efficient operation.

(PowerPoint Slides 7 and 8)

- G. Air-boom sprayers use a blower unit to carry small spray droplets into the target.
 - 1. Lower volume of carrier is used due to better coverage and reduced drift.
 - 2. Adding air-assist equipment can increase the cost of a standard sprayer.
 - a. Because of the added cost, use has been confined to high-value specialty crops and vegetables.
 - b. A low-cost alternative is to use a system that mixes air and chemical at the nozzle.
- H. Foggers and rope wick applicators are not really sprayers, but are used to apply liquid herbicides. Foggers apply pesticides, usually insecticides, as very fine droplets called aerosols. A single aerosol droplet is too small to see, but a concentration of droplets is visible, floating in the air like smoke or a cloud. Aerosol generators are frequently called foggers. Foggers are used to completely fill or blanket an area with insecticide and are most often used in enclosed spaces. Fine particles are easily moved by air currents before they contact all target insects. Rope wick applicators apply liquid herbicide by wiping it onto the plants. The pesticide in a pipe soaks out through rope segments, as the applicator crosses the field. The plants which reach above the pipe are contacted and the herbicide is wiped off the rope onto the plants.
- I. Direct injection systems offer convenience and safety benefits. The basic design is one that holds undiluted pesticide and water or carrier in separate tanks. Undiluted pesticide is metered into nozzle lines by pumps or air pressure for blending with the carrier before it reaches the nozzle. This eliminates the need to add and mix chemicals in the spray tank, so there is no tank contamination. The chemical may be held in the original container, in a chemical carrying tank or in a sealed, returnable container. The returnable containers virtually eliminate all pesticide handling and disposal of the empty containers.

PowerPoint Slides 9 and 10 illustrate different types of sprayers. Use TM: 5-1 (PowerPoint Slide 11) to discuss proper protective clothing when mixing and spraying pesticides. Refer to the safety lessons and the content learned there. Use TM: 5-2 to discuss different categories of liquid pesticide application equipment. Compare and contrast the various applicators and sprayers.

Objective 2: Describe the selection of sprayers and their components.

Anticipated Problem: How are sprayers selected and what are their components?

(PowerPoint Slide 12)

II. Sprayers come in different sizes, shapes, and brands.

(PowerPoint Slide 13)

- A. Sprayers and other application equipment have three basic functions.
 - 1. Storage of chemicals prior to application in the field.
 - 2. Metering the quantity of material being applied.
 - 3. Distribution of the material into the desired pattern.
- B. Sprayers are composed of numerous components. Many different arrangements and combinations may be used.

(PowerPoint Slide 14)

- 1. For a particular situation, the best combination depends on four factors.
 - a. The chemical being applied.
 - b. The application rate.
 - c. The crop being treated.
 - d. The required accuracy.

(PowerPoint Slides 15 and 16)

- 2. Sprayers may have the following components.
 - a. Sprayer tanks should have sufficient capacity, be easy to fill and clean, be corrosion resistant, and have a shape suitable for easy mounting and effective agitation.
 - b. Most sprayers are equipped with some kind of agitator to maintain a uniform mixture. There are three agitation systems.

(PowerPoint Slide 17)

- 1. Mechanical agitators are propellers or paddles mounted on a shaft near the bottom of the tank.
- 2. Hydraulic agitation returns a portion of the pump output to the tank and discharges it through a series of orifice in a boom along the bottom of the tank or through a volume booster nozzle.
- 3. ***Air sparging*** is agitation by bubbling air through the liquid.

(PowerPoint Slides 18 and 19)

- c. The ***pump*** moves liquids from the tank to the nozzles and creates pressure to propel spray droplets to the target. There are five types of pumps.

(PowerPoint Slide 20)

1. Diaphragm pumps have a flexible diaphragm that produces the pumping action. They are popular for medium-pressure applications and are durable because moving parts are sealed in an oil bath.
2. Centrifugal pumps are simple in design and durable. They can be used with abrasive materials for low-pressure sprayers. Pumping action is created by a high speed impeller that forces liquid out of the pump. Centrifugal pumps are not self-priming, so they are mounted below the supply tank.

(PowerPoint Slide 21)

3. Piston pumps are self-priming and have high pressure capabilities. One or more pistons travel inside cylinders and force liquid through one-way valves. Piston pumps are positive displacement, where output is proportional to speed and is virtually unaffected by pressure.
4. Most metering pumps are driven by a ground wheel. When ground speed changes, the rate of pumping increases or decreases proportionately.

(PowerPoint Slide 22)

5. Roller pumps consist of cylindrical rollers that move in and out of slots in a spinning rotor. As the rotor spins, it creates space for liquid during half its rotation. Then, liquid is discharged from the pumping chamber during the remainder of the rotation. Roller pumps are self priming, easy to repair, inexpensive, and operate efficiently at power take off (PTO) speeds.

(PowerPoint Slide 23)

- d. A **relief valve** is a safety device that releases liquid when the pressure exceeds a safe level. Relief valves can be used to regulate sprayer pressure by adjusting them to open at the desired setting.
- e. The **pressure gauge** is used to measure the pressure in the system and is a valuable tool for diagnosing sprayer problems.
- f. **Strainers** and **screens** are used to remove particles from the system. They are commonly used in three places.

(PowerPoint Slide 24)

1. Tank screens are coarse screens that remove twigs and other large foreign material when the tank is filled.
2. Line strainers are necessary to prevent rust, scale, sand, or other small foreign materials from entering and damaging the pump.
3. Nozzle strainers move fine particles that could clog nozzles.

(PowerPoint Slide 25)

- g. Pipes and hoses convey the liquid through the sprayer. Liquid pressure varies at different points on the sprayer. Hoses and pipes must be strong enough to prevent bursting.
- h. Sprayer frames must be strong and durable and provide convenient points for attaching the boom and mounting other components.

- i. **Control valves** are used to start and stop flow of liquid to the nozzle. They are independent of the pressure regulator. Control valves may be operated manually or electronically, and typically break the boom into two or three controllable sections.

(PowerPoint Slides 26, 27, and 28)

- j. Selection of the correct type and size of spray nozzle is essential for each application. The nozzle determines the amount of spray applied to an area, the uniformity of the application, the coverage of the sprayed surface, and the amount of drift. **Nozzles** meter liquids, atomize the liquid stream into droplets, and disperse droplets in a specific pattern. For a liquid, the flow rate depends on the effective size of the orifice and the pressure. Nozzle flow rate increases as pressure increases, but it is not proportional. Doubling the pressure does not double the flow rate. Pressure must be increased by a factor of 4 to double the flow rate. **Atomization** is the liquid breakup caused by the tearing action of the air. Liquid exits from the nozzle in an unstable sheet which breaks up into droplets. Droplet size is measured in microns, one micron is one millionth of a meter. Droplet size is affected by nozzle type and size, pressure, and liquid characteristics. As pressure increases, average droplet size decreases to a certain limit. Spraying nozzles are described according to the shape of the application pattern. Nozzles have been developed for practically every kind of spray application, but only a few are used in pesticide applications. These include the following:

(PowerPoint Slide 29)

1. Flat-fan nozzles apply uniform coverage across the entire width of the spray pattern, and should only be used for banding pesticides over the row.
2. Extended-range flat-fan nozzles are frequently used for soil and foliar applications when better coverage is required.

(PowerPoint Slide 30)

3. Wide angle flat fan nozzles allow for application over a wider area.
4. Even spray nozzles provided consistent, uniform coverage over the area.

(PowerPoint Slide 31)

5. Hollow cone nozzles produce coverage around a plant without actually covering the plant.
6. Full cone nozzles produce large droplets over a wide range of pressures.

Use TM: 5-3 (PowerPoint Slide 15) to illustrate the major components of a sprayer. To discuss some pumps used in sprayers, use TM: 5-4 (PowerPoint Slide 19). Types of sprayer nozzles and spray patterns are illustrated in TM: 5-5 (PowerPoint Slide 32). TM: 5-6 (PowerPoint Slide 33) provides a nozzle guide for band and directed spraying.

Objective 3: Explain the operation of a sprayer.

Anticipated Problem: How are sprayers operated?

(PowerPoint Slide 34)

III. Sprayer operation includes all activities, before, during, and after field use, that affect the quality of field. The following is a list of general guidelines to use when planning and conducting spraying.

(PowerPoint Slides 35 and 36)

- A. Preliminary planning begins with the decision to apply a pesticide and to choose the particular chemical to be used. While selecting the chemical, several decisions must be made such as how it is to be applied, application rate, number and placement of nozzles, proper operating speed, nozzle tips needed for desired application rate, nozzle spacing, and travel speed.
- B. Preliminary adjustment and setting based on label recommendations.
- C. Proper calibration to ensure that the area being sprayed receives the right amount of chemical.
- D. There are two factors to consider before loading a sprayer.
 - 1. The quantity of pesticide to add to the tank and procedures to follow while mixing the pesticide.
 - 2. Determine the amount of pesticide to add to the tank, sprayer-tank size, and amount of pesticide needed per treated acre must be known.
- E. Transport loaded sprayer as little as possible. An accident could spill a load of chemicals on the road or in a ditch, where it could be very hard to contain and cleanup.
 - 1. Mix as close to the field as possible and spray the entire load immediately.
 - 2. Lock the boom or booms in the transport position and use accessory lights, and other devices to warn operators of other vehicles.
- F. During field operation, the operator must maintain constant ground speed and pressure as determined while calibrating. Monitoring the operation continuously for plugged nozzles, marker operation, leaks, weather, empty tank, and obstacles.
- G. A sprayer should be carefully cleaned after application of each different pesticide, at the end of the season, and when repairs must be made.
 - 1. Before cleaning the sprayer, review the pesticide label for any special recommendations. Commercial cleaning compounds are available.
 - 2. The cleaning site should be located away from water supply sources, people, and pets to prevent contamination.
 - 3. Wear protective clothing, including rubber boots, gloves, and goggles.
 - 4. The cleaning area should have a wash rack or cement apron, plus a sump to catch wash water and pesticides. The water and chemicals collected can be reapplied to the treated area, but only at a rate that does not exceed the maximum use rate listed on the pesticide label.
 - 5. Store the sprayer in a dry, clean building. Polyethylene tanks and hoses need protection from sunlight to avoid damage.

Use TM: 5-7 (PowerPoint Slide 37) to illustrate the proper cleaning of application equipment. Discuss the consequences of improper or lack of cleaning.

Objective 4: Describe the calibration of sprayers.

Anticipated Problem: What are the procedures to follow when calibrating sprayers?

(PowerPoint Slides 38 and 39)

IV. Most performance complaints about pesticides can be traced to poor application practices. Proper calibration helps insure that the area being sprayed receives the right amount of chemical. Nozzle flow rate, ground speed of the sprayer, and width sprayed per nozzle are variables that affect the amount of spray material applied per hectare.

(PowerPoint Slide 40)

- A. Determine the amount of pesticide needed for each tankful or for the area to be sprayed. Add the pesticide to a partially filled tank of carrier (water, fertilizer, etc.), then add the carrier to the desired level with continuous agitation.
- B. Operate the sprayer in the field at the ground speed measured and at the pressure determined. After spraying a known number of hectares, check the liquid level in the tank to verify that the application rate is correct.
- C. Check the nozzle flow rate frequently. Adjust the pressure to compensate for small changes in nozzle output due to nozzle wear or variations in other spraying components. Replace nozzle tips and recalibrate when the output has changed 10 percent or more from that of a new nozzle, or when the pattern has become uneven.

Discuss different methods of determining the correct amount. Also, investigate what may go wrong if the sprayer is not calibrated properly.

Objective 5: Identify how sprayers are maintained.

Anticipated Problem: How are sprayers maintained?

(PowerPoint Slides 41 and 42)

- V. Preventative maintenance should be given first consideration in the use of sprayers in order to reduce the chances for breakage, costly repair bills, and loss of time.
 - A. Adequate and timely adjustment, repair, lubrication, and protection from the weather determines the life of a machine.
 - 1. Consult the operator's manual for lubrication instructions for the machine and for the location of the parts to be lubricated.
 - 2. Make certain all tires are inflated to the recommended pressure to provide level machine operation.
 - 3. Inspect hoses, connections, and gauges for cracks or damage on a regular basis.
 - 4. Inspect the boom and frame before, during and after the season.
 - B. All spray equipment should be thoroughly cleaned inside and outside immediately after it is used. When cleaning equipment, always wear protective clothing, including rubber boots, a rubber apron, goggles and possibly a respirator. Clean-up is important because many chemicals rapidly corrode some metals and may react with succeeding chemicals. Pesticide residue that is not removed from the sprayer system after application may damage the next crop or contaminate the next crop with illegal residue.

Discuss with the students the advantages of maintenance of sprayer systems. Relate this to the maintenance of other agricultural equipment you have already discussed.

Review/Summary: Focus the review and summary around the lesson's learning objectives. **(PowerPoint Slide 43)** Use classroom discussion to determine which areas, if any, need to be covered in more detail.

Evaluation: Evaluation should focus on student achievement of the objectives for the lesson. Various techniques can be used, such as student performance on the written test.

Answers to Sample Test:

Matching

1. D
2. F
3. E
4. B
5. C
6. A

Fill-in-the-blank

1. Air sparging
2. Pressure
3. Control valves
4. Calibration

Short Answer

1. Nozzle flow rate, ground speed of the sprayer, and width sprayed per nozzle.
2. Pressure must be increased by a factor of 4 to double the flow rate.

Operating, Calibrating, and Maintaining Spraying Systems

Name: _____

Matching: Match each word with the correct definition.

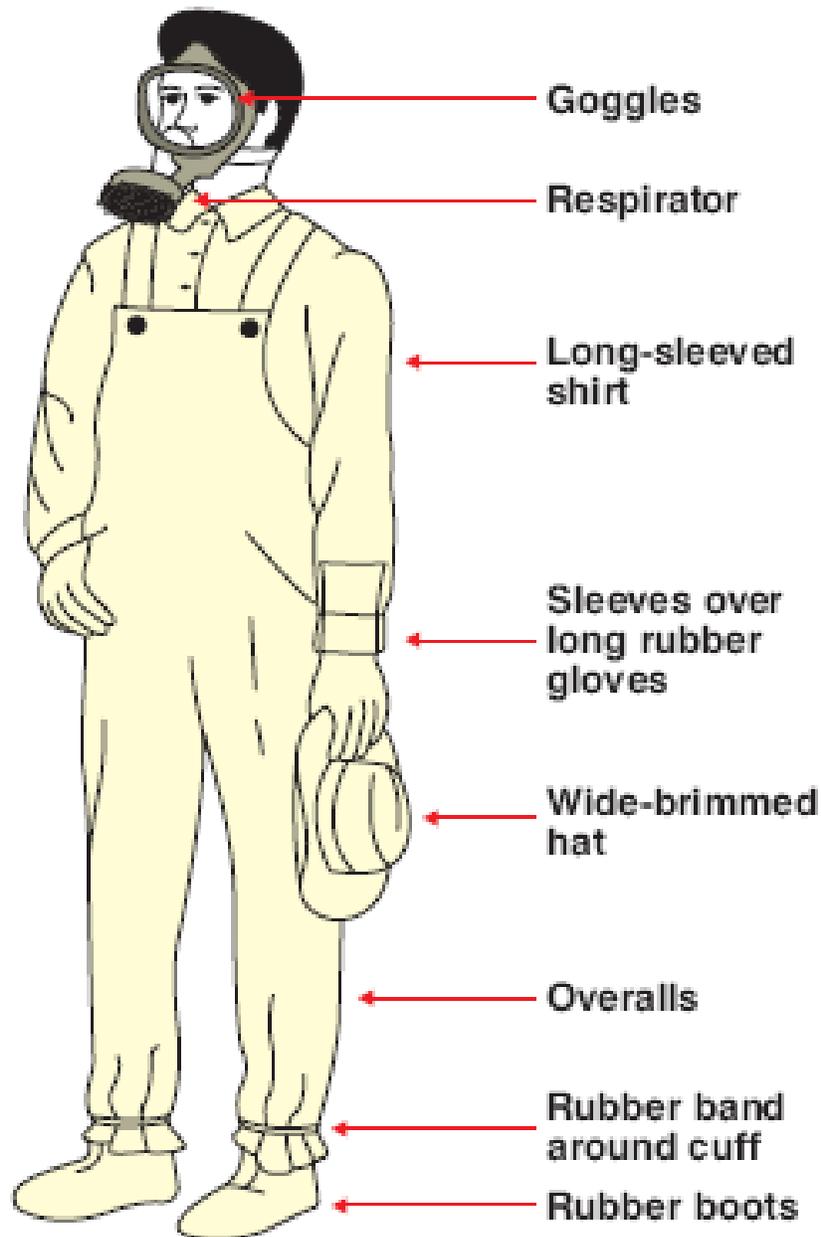
- | | |
|-------------------|-----------------|
| a. atomization | d. pump |
| b. nozzles | e. relief valve |
| c. pressure gauge | f. strainers |

- _____ 1. Moves liquid from the tank to the nozzles and creates pressure to propel spray droplets to the target.
- _____ 2. Used to remove particles from the system.
- _____ 3. Safety device that releases liquid when the pressure exceeds a safe level.
- _____ 4. Meter liquids, atomize the liquid stream into droplets and disperse droplets in a specific pattern.
- _____ 5. Used to measure the pressure in the system.
- _____ 6. Liquid breakup caused by the tearing action of the air.

Fill-in-the-blank: Complete the following statements.

1. _____ is agitation by bubbling air through the liquid.
2. Relief valves can be used to regulate sprayer _____ by adjusting them to open at the desired setting.
3. _____ are used to start and stop flow of liquid to the nozzle.
4. Proper _____ helps insure that the area being sprayed receives the right amount of chemical.

PESTICIDE SAFETY

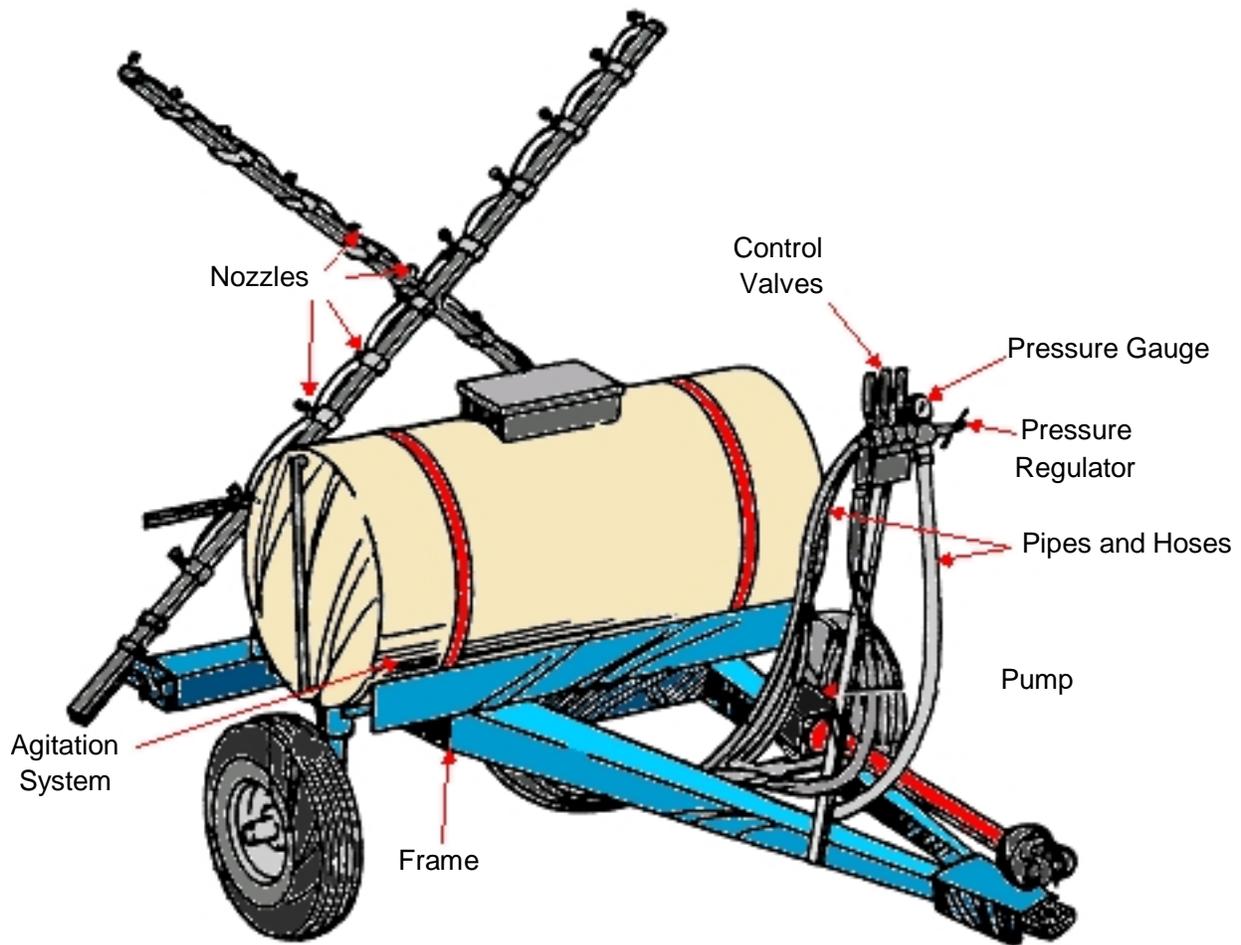


Consult the manufacturer guidelines regarding protective clothing when mixing and spraying pesticides.

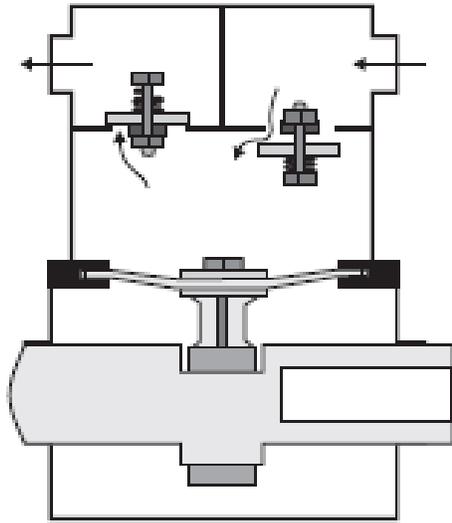
CATEGORIES OF LIQUID PESTICIDE APPLICATION EQUIPMENT

1. Hand operated sprayers
2. Knapsack or backpack sprayers
3. Low pressure sprayers
4. Control droplet applicators
5. High pressure sprayers
6. Air-carrier/air-blast sprayers
7. Air-boom sprayers
8. Foggers and rope wick applicators
9. Direct injection systems

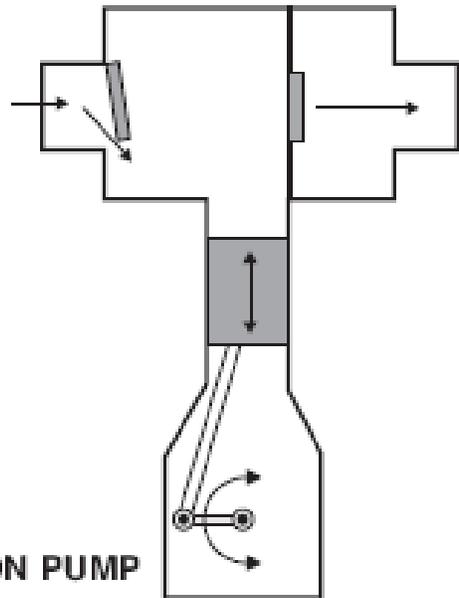
MAJOR COMPONENTS OF A SPRAYER



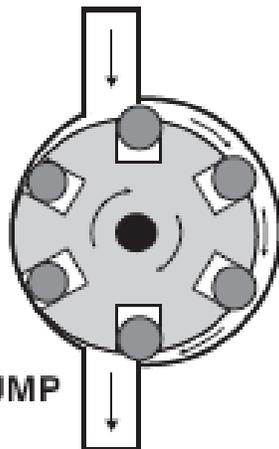
SOME PUMPS USED IN SPRAYERS



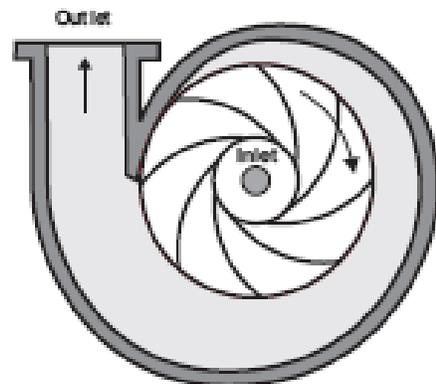
DIAPHRAGM PUMP



PISTON PUMP



ROLLER PUMP



CENTRIFUGAL PUMP

TYPES OF SPRAYER NOZZLES



FIGURE 1:
Flat fan spray pattern



FIGURE 2:
Extended range flat fan spray pattern



FIGURE 3:
Wide angle flat fan spray pattern



FIGURE 4:
Even spray pattern



Overlap broadcast pattern



Band spray application



FIGURE 5:
Hollow cone spray pattern



FIGURE 6:
Full cone spray pattern

NOZZLE GUIDE FOR BAND AND DIRECTED SPRAYING

Nozzle guide for band and directed spraying.

	 Even Flat Fan	 Twin Even Flat Fan	 Hollow Cone	 Full Cone	 Disc and Core Cone
Herbicides					
Pre-emerge	Very Good	Good		Good	
Post-emerge Contact	Good	Very Good	Very Good		
Post-emerge Systemic	Very Good	Good			
Fungicides					
Contact	Good		Good		Very Good
Systemic	Very Good				Good
Insecticides					
Contact		Very Good	Very Good		Very Good
Systemic	Very Good				Good
Growth Regulators	Good			Very Good	

CLEANING APPLICATION MACHINERY



A. Wash sprayer with brush and soapy water. Wear protective clothing, boots, gloves, hat, and goggles.

B. Hose off the machine.
C. Wash the tires with a brush.



D. Pump soapy water through the nozzles.

