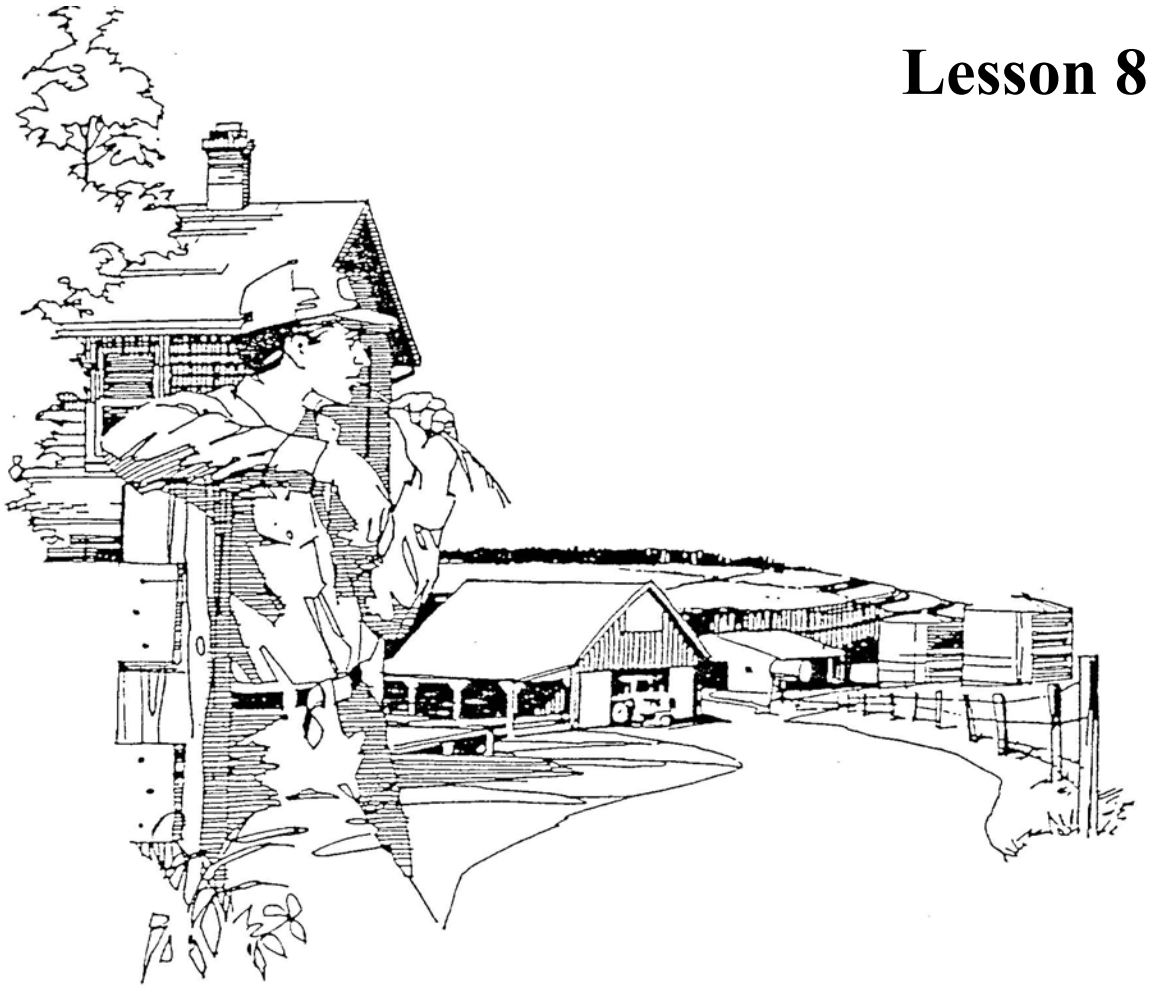
Pesticide Applicator Course for Agricultural Producers

Lesson 8



Application Equipment

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Application Equipment

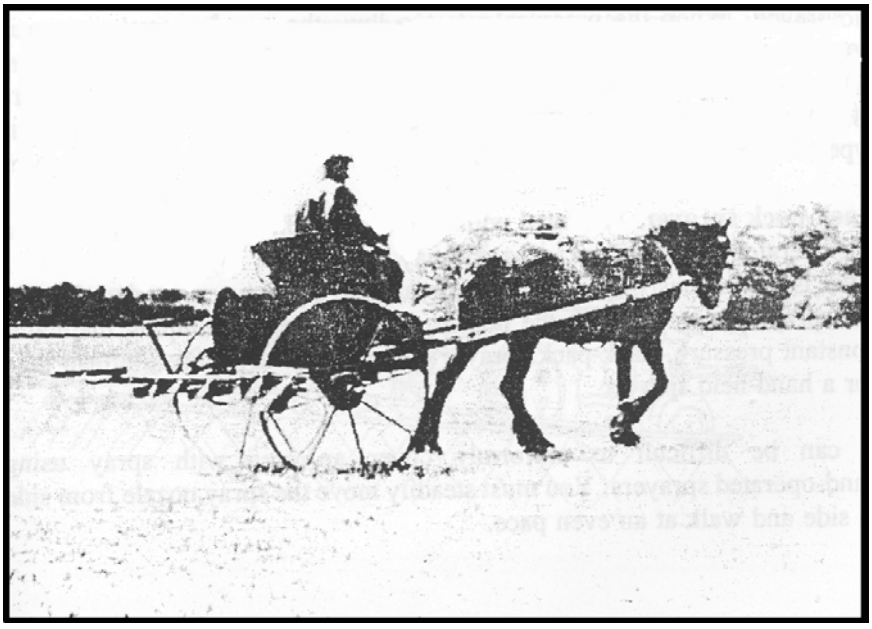
What You'll Learn!

The purpose of Lesson 8 is to familiarize you with common types of pesticide application equipment. This lesson also describes sprayer parts, factors affecting spraying, and procedures for cleaning a sprayer. The experienced grower will already know much of this.

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

- **name common types of pesticide application equipment and describe their uses;**
- **describe what to consider when selecting sprayer tanks, pumps, hoses, filters, regulator valves, and pressure gauges;**
- **describe parts of a typical spray nozzle and explain which nozzle tip materials wear most quickly;**
- **list four types of nozzle spray patterns and describe their use;**
- **explain how you can change nozzle output and spray droplet size and why they are important;**
- **describe basic cleaning procedures for a sprayer.**

"Application equipment has changed a lot over the years...."



Types of Application Equipment

A wide variety of equipment is available for applying pesticides. Good results occur only if you select equipment suitable for your application, set it up and use it correctly, and maintain it so it operates properly.

All growers are expected to have a general knowledge of hand-operated sprayers, boom sprayers, granular applicators, and wick applicators. In addition, tree fruit and strawberry growers should be familiar with air-blast sprayers; and greenhouse growers should be familiar with misters, foggers, and smoke fumigators.

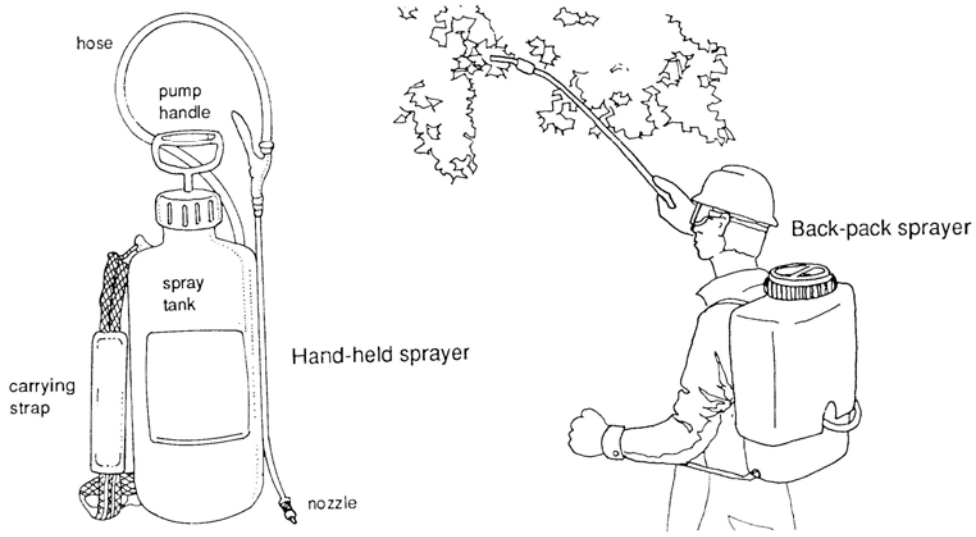
Hand-Operated Sprayers

Hand-operated sprayers are used to apply small quantities of pesticides inside greenhouses or to do small jobs outdoors such as weed control around buildings. They may be either hand-held or back-pack type sprayers.

Hand-held sprayers have an air pump which compresses air into the tank and pressurizes the spray mixture. The pressure slowly drops as the liquid is sprayed. When the pressure gets too low, the nozzle spray pattern is poor. You must stop spraying and pump to rebuild the pressure. This must be done at frequent intervals in order to maintain normal operating pressure of between 200 and 500 kPa (30 to 80 psi). The capacity of tanks on this type of sprayer ranges between four and ten litres.

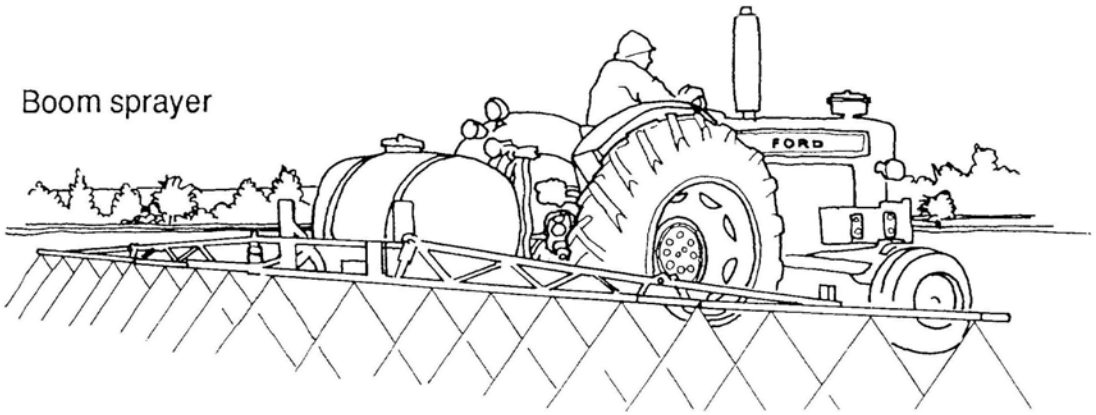
Back-pack sprayers are fitted with a harness so the unit can be carried on the operator's back. Tank capacity may be as large as 20 litres. A hand lever is continuously operated to pump air into a pressure cylinder, forcing the spray mixture through the nozzle. Because steady pumping maintains constant pressure, back-pack sprayer output is usually more uniform than for a hand-held sprayer.

It can be difficult to uniformly cover an area with spray using hand-operated sprayers. You must steadily move the spray nozzle from side to side and walk at an even pace.

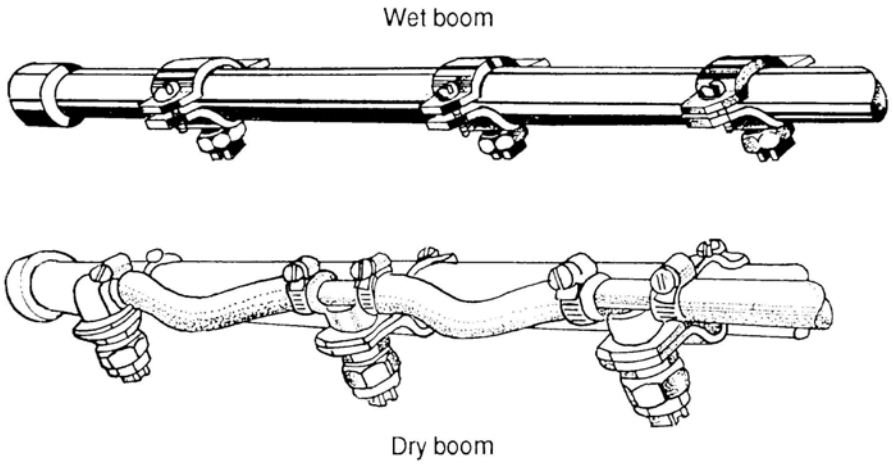


Boom Sprayers

Boom sprayers are the most common pesticide application equipment used in agriculture. These sprayers have a power-driven pump which delivers spray mixture under pressure to a set of nozzles (and sometimes to a hand-operated spray gun for spot treatments). The nozzles are usually arranged along a boom at regular intervals (e.g., 50 cm; 20 inches) or spaced according to crop row spacing. Boom sprayers may be mounted on a tractor, truckbed, or trailer. Spray tank capacity can be as large as 4,000 litres with boom lengths reaching 24 metres (80 feet) or more. Pumps are driven by the tractor PTO (power take off) or a hydraulic motor.

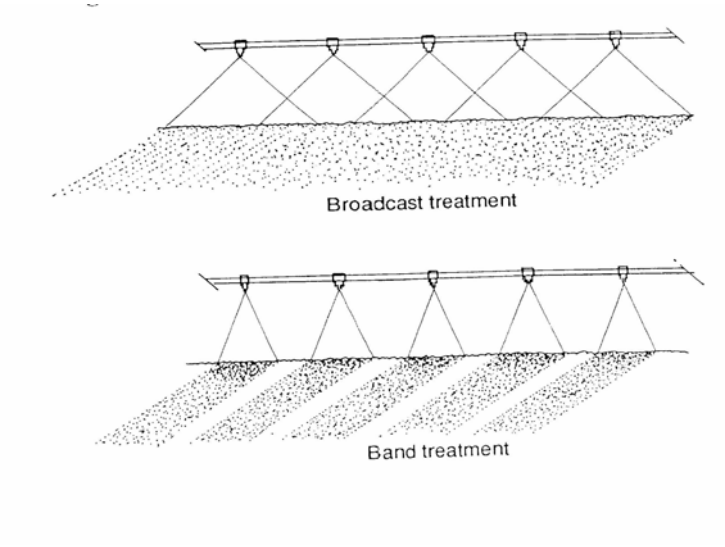


Booms on sprayers may be called wet or dry booms. A wet boom consists of a pipe (preferably stainless steel) into which the nozzle bodies are inserted. The spray mixture is pumped into the boom and out the nozzles. With a dry boom a solid pipe acts as a support for nozzles connected by short lengths of flexible hose. The spray mixture is pumped through the hose, not the boom. Dry boom nozzle spacing can be easily adjusted for different row crops.

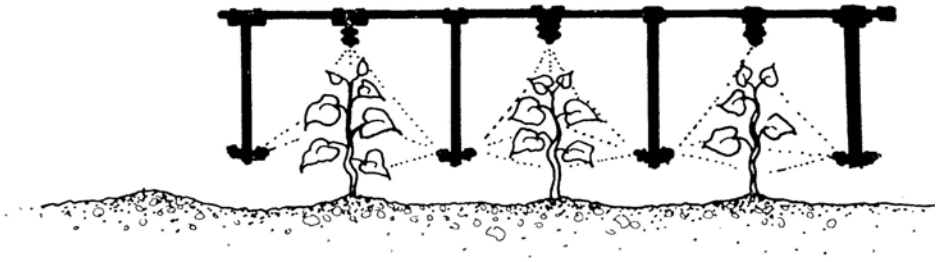


Booms longer than nine metres (30 feet) should be supported by outrigger wheels to keep the boom at a uniform height. Long booms need to be well braced to keep them from sagging and bouncing. Bouncing distorts the spray pattern.

Pesticide applied over the full width of the boom (not just rows) is known as a broadcast treatment. For broadcast treatment, nozzles are spaced so that spray patterns overlap. This provides uniform spray coverage along the boom.

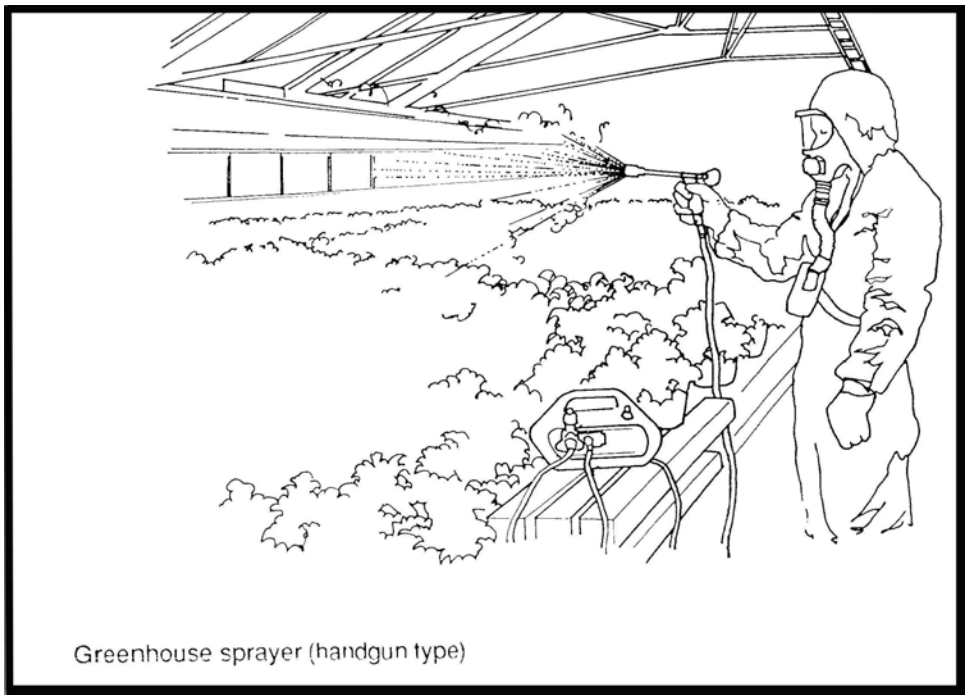


Application of a pesticide in a strip between or over each crop row is called a band treatment. Nozzles are spaced so that spray is directed over or between crop rows as required. The boom may be fitted with nozzles on drop pipes to improve spray coverage of soil or plants in each band.



Boom fitted with nozzles on drop pipes.

Boom-type sprayers can be adapted for use in greenhouses. The boom may move along a track which runs above the crop. In other systems the boom may be replaced by a spraygun with a single nozzle or an array of nozzles. Tanks and pumps may be permanently installed in one location or smaller units may be mounted on wheels.



Greenhouse sprayer (handgun type)

The separate parts common to all boom sprayers are discussed in more detail toward the end of this lesson.

Granular Applicators

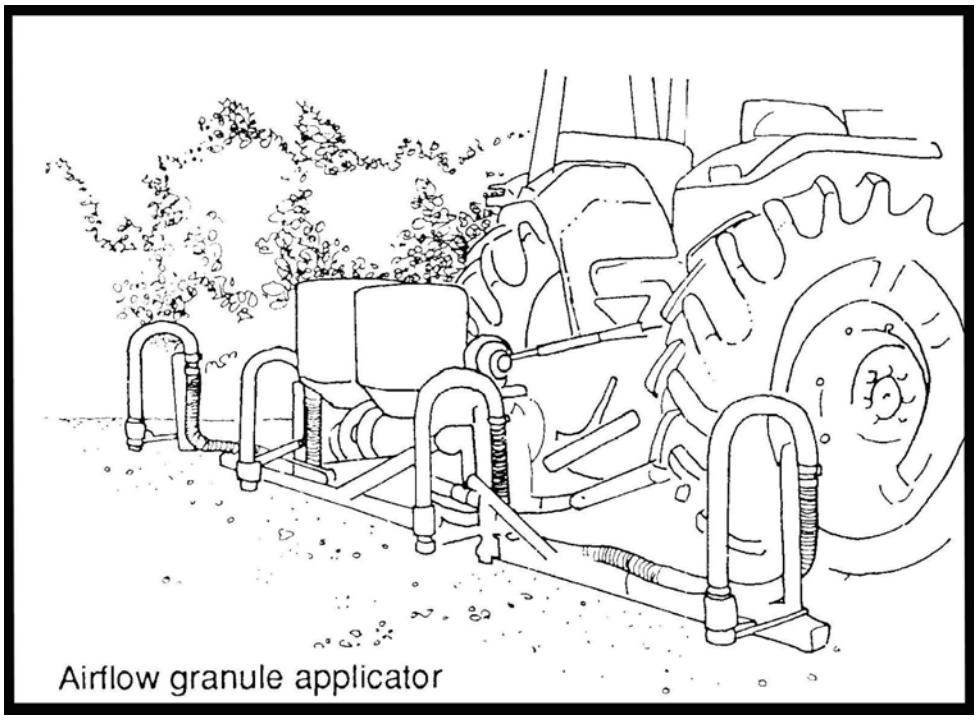
Granular applicators are used to apply granular pesticides to soil. Granules must be incorporated (mixed in with the soil) during or immediately following application. Incorporation in the soil prevents birds from eating the granules; also, contact with soil moisture activates the pesticide.

There are several types of equipment for granular application. Generally the granules are held in a hopper which has one or more metering devices (adjustable openings) at the bottom. There may also be an auger or notched rotor in the hopper bottom to deliver a constant amount of granules to the discharge opening.

The most accurate type of distribution system for broadcast application has many downspouts or delivery tubes evenly spaced along a boom. These downspouts or delivery tubes move the granules from the metering device to the ground. Units referred to as pneumatic applicators use a stream of air to carry granules through the delivery tubes.

Granules may be applied in several ways:

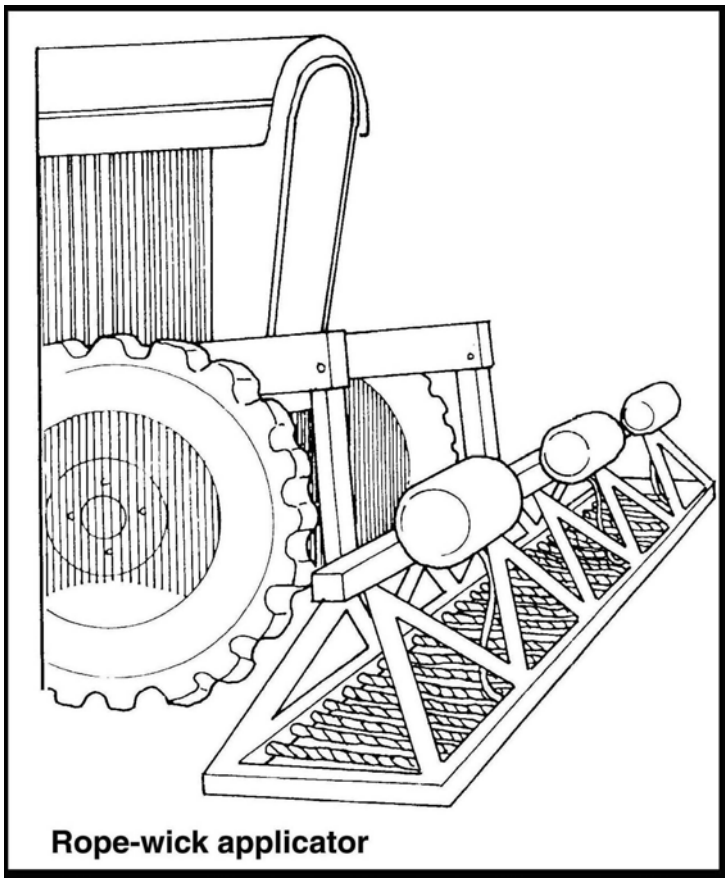
- **Broadcast - the pesticide is applied uniformly to the total area of the field being treated. The pesticide is usually incorporated after application.**
- **Band - the pesticide is applied uniformly in bands leaving untreated strips in the field. Band treatments are usually made over the row of a crop when planting. The pesticide is immediately incorporated into the soil with a chain or a harrow.**
- **In-furrow - the pesticide is placed underground in a narrow furrow during planting.**


Airflow granule applicator

The speed travelled while applying granules should be slow enough to prevent bouncing of the equipment as this causes uneven application. The application rate can be adjusted by changing the discharge opening. The actual rate of output must be checked during calibration (described in Lesson 9).

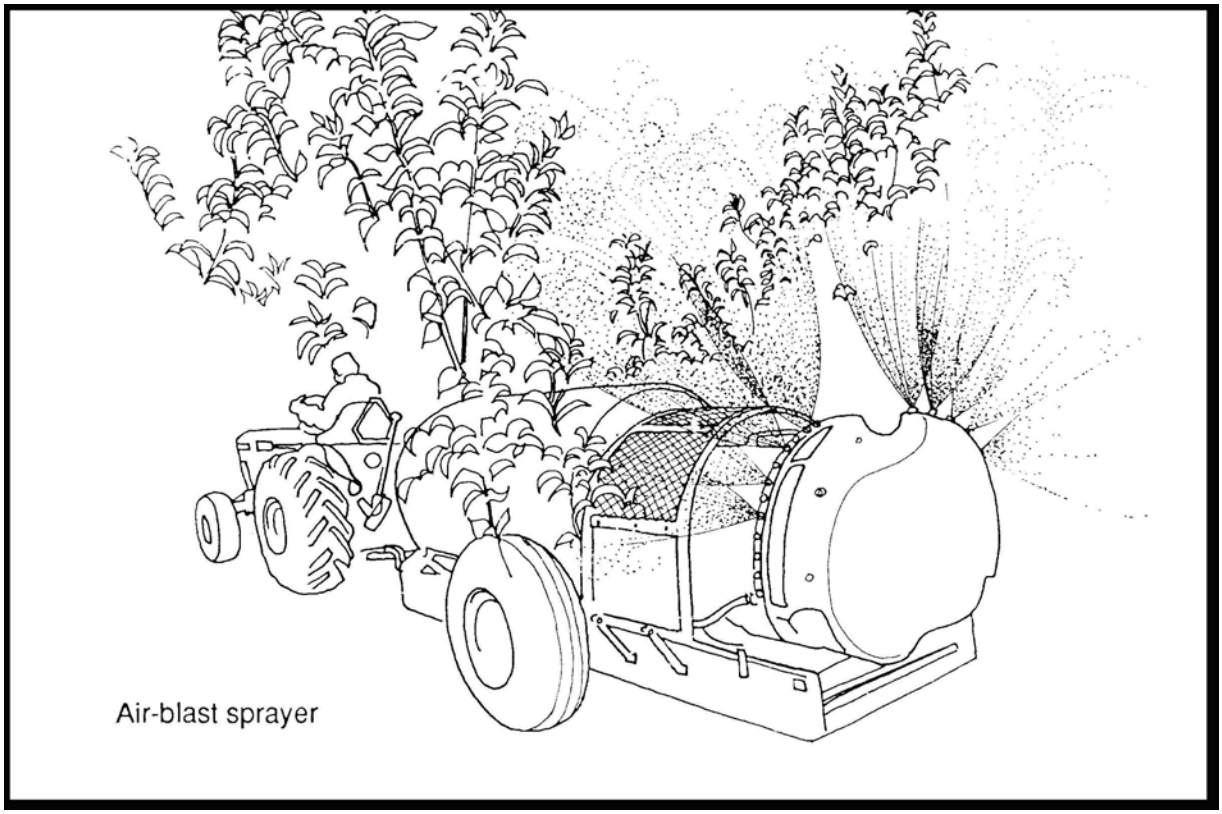
Wick Applicators

Wick applicators are used to selectively apply liquid herbicide by wiping it onto plants. They can be useful where no spray drift can be tolerated. Wicks are made of a special wick rope or absorbent pads. A concentrated herbicide mixture is wicked or pumped from a tank or pipe onto the wick which is then wiped on weeds growing above crop plants or between crop rows. Wick applicators are often constructed to suit special needs. Pumps, control devices, and nozzles are minimal or eliminated and tanks are quite small because a small amount of concentrated herbicide is applied. Hand-held wick applicators can be used for spot treatment of weeds like Canada thistle in pastures.



Air-Blast Sprayers

Air-blast sprayers (also called air-carrier sprayers) are commonly used for applying insecticides and fungicides to orchards and berry crops. Pesticide mixture is pumped through nozzles into a blast of air from a high speed fan. The air blast breaks the liquid into fine droplets and transports them to the target trees or vines. From six to eight nozzles, either cone or air shear type, are arranged in an arc on manifolds located each side of the sprayer. The air blast may be directed from one or both sides of the sprayer as it moves forward between trees or rows.



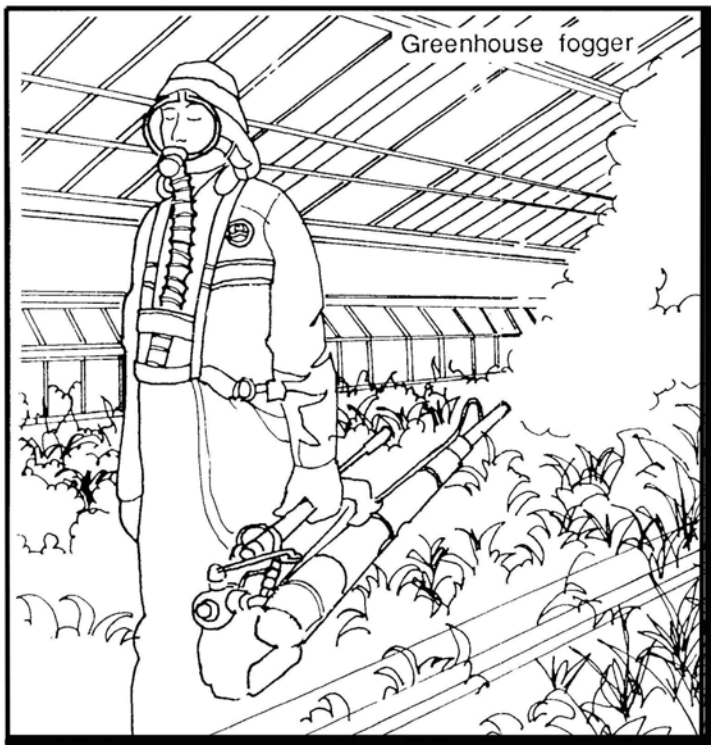
Air-blast sprayers provide better penetration and coverage of trees and vines than could be obtained with boom sprayers. However, the small droplet size (fine spray) of air-blast sprayers is easily carried away from the target if there is any wind. Uniform coverage is very difficult in winds over 5 km/h. High temperatures or low humidity may evaporate the small droplets before they can reach the target.

Misters, Thermal Foggers, and Smoke Fumigators for Greenhouses

Specialized equipment has been developed to apply insecticides and fungicides in the enclosed spaces of greenhouses. They are often named by the kind of particles they produce, namely mists, fogs, and smoke. Misters and foggers are also called aerosol generators.

When using aerosol or smoke generators, the treated space should remain sealed with window, doors, and ventilators closed for the time indicated on the label (e.g., four hours or overnight). Greenhouse staff should be notified and doors should be locked and posted with a warning sign to prevent entry to the treated space. The greenhouse should be aired out for the specified time before reentry is allowed.

Misters produce small spray droplets in the mist size range. These units can be portable or permanently installed. They are usually electrically powered. The larger units use compressed air to force the spray solution through a small nozzle. A fan may be used to distribute the mist throughout the greenhouse. Mist formed by this equipment is usually effective in covering dense foliage.



Foggers are usually portable machines that produce droplets smaller than those produced by a mister. The fog may be distributed with a fan through the greenhouse and can penetrate dense foliage. The fine droplets of pesticide remain suspended for many hours and kill insects or mites on contact. Most of the pesticide is vented out of the greenhouse during aeration, after which pest control stops.

There are two main types of foggers. Cold foggers produce the fog by spinning discs or by utilizing fine nozzles under high pressure. Thermal foggers use heat to vaporize a special oil formulation of pesticide. As the pesticide vapor is released into the cooler air it condenses into very fine droplets, producing the fog.

Smoke fumigators (smoke bombs) come ready-to-use in a can. When the fumigant in the can is ignited, the smoke carries the pesticide throughout the greenhouse and will kill insects on contact. Like pesticide fogs the smoke is removed during aeration, after which pest control stops.

Each smoke fumigant can is sufficient for a certain volume of greenhouse (e.g., 300 cubic metres; 11,000 cubic feet). The volume of the greenhouse must first be calculated to determine the number of cans required.

When several cans are needed, they should all be put in place, then ignited in sequence starting furthest from the exit door. If fumigators are needed in more than one aisle, workers in each aisle should light the fumigators in unison, starting furthest from the exit door. Workers must avoid contact with the smoke.

Quiz 8.1 - Types of Application Equipment

1. Of the two hand-operated sprayers mentioned (hand-held and back-pack), which can give you the most even spray coverage? Why?

_____

_____

2. Spray booms longer than nine metres (30 feet) need extra support such as outrigger wheels to stop them from bouncing. Why?

_____

_____

3. What is another common cause of bouncing spray booms?

_____

_____

4. What is the major difference between broadcast and band treatments?

_____

_____

5. What are two reasons granules should be incorporated during or immediately after application?

_____

_____

6. What three weather conditions can cause problems for the small droplets from air-blast sprayers? What are those problems?

_____

_____

7. Which produces larger droplets - a mister or a fogger?

_____

_____

8. What is the difference between a cold fogger and a thermal fogger?

_____

_____

9. A greenhouse is about to be smoke fumigated with three smoke bombs in each of two aisles. What is the minimum number of people needed to ignite them? Which of the three bombs in each aisle do they ignite first?

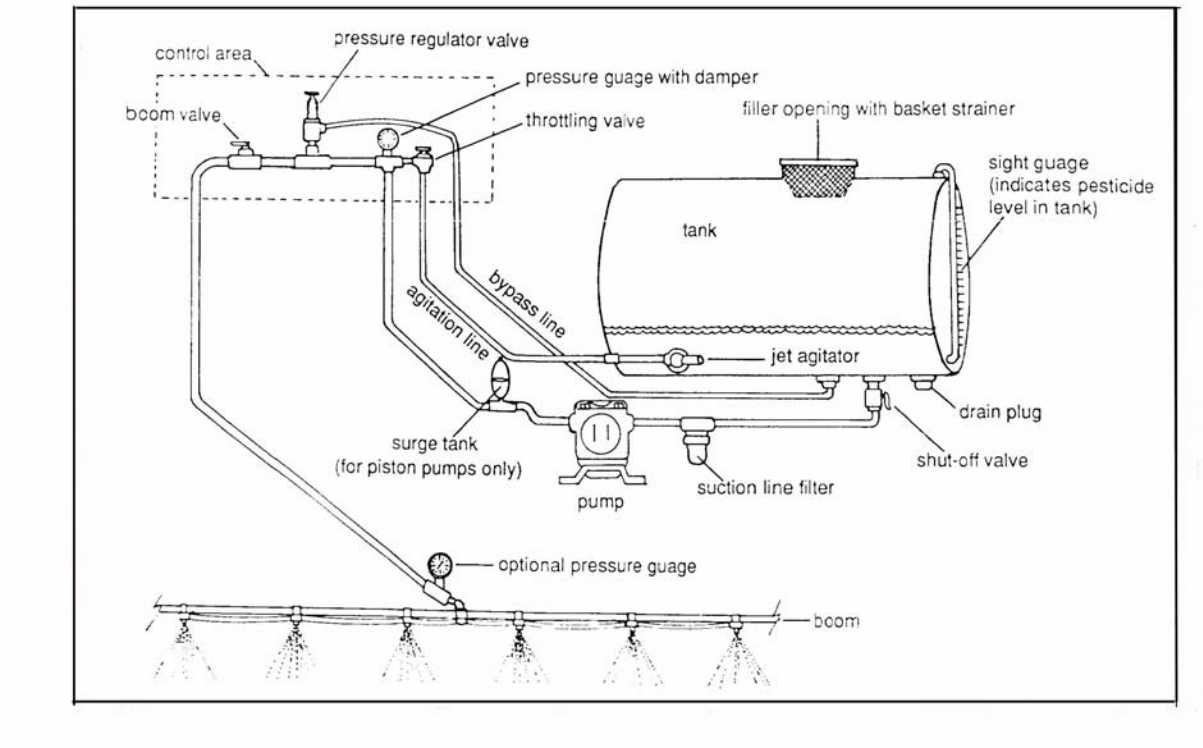
_____

_____

Now check your answers against the Answer Key at the end of the lesson. If you've done well, continue with Lesson 8. If not, review those sections that gave you trouble before proceeding any further.

Boom Sprayer Parts

More pesticides are applied with boom sprayers than any other type of equipment. You should be able to describe major parts of a boom sprayer, how they operate, and the desirable features of these parts. (Most of these parts are common to other powered equipment such as air-blast sprayers.) The diagram below names the parts you should be familiar with.



Spray Tanks

Things to consider when purchasing spray tanks are materials, shape, and size.

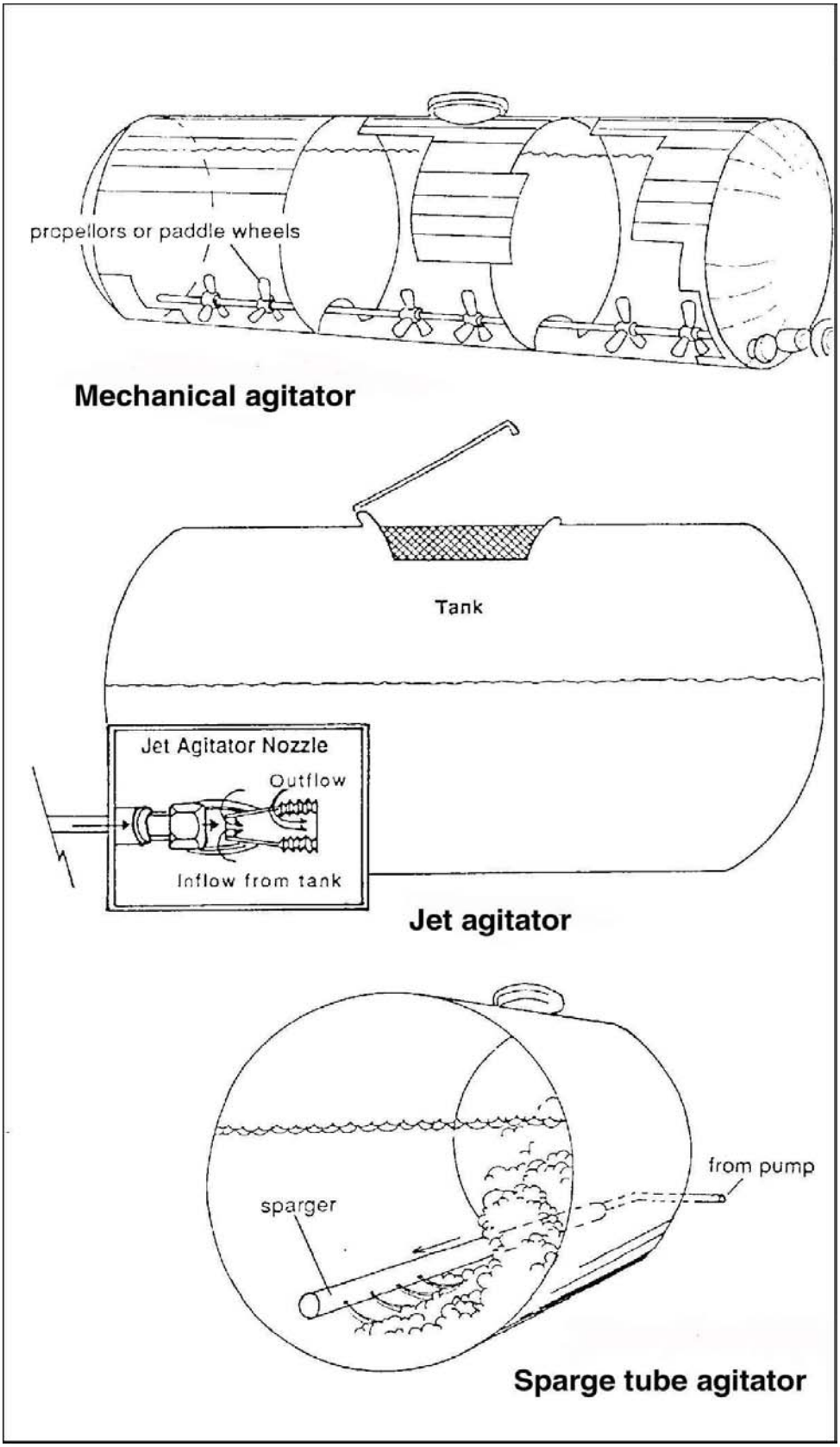
Materials: Fibreglass or polyethylene tanks are relatively inexpensive and for this reason are popular for capacities of less than 1,000 litres. However, when left in the open and exposed to the sun, these materials become brittle and are easily damaged. Larger tanks of these materials must be mounted on a "saddle" to provide solid support over a large area of the tank.
Galvanized steel is susceptible to corrosion from a variety of pesticides. It should not be used with chemicals such as Roundup as a hazardous chemical reaction can result. Stainless steel is the highest quality material for sprayer tanks.

Shape: Oval and cylindrical-shaped tanks are popular because they are easy to clean and allow for more effective agitation. Tanks with flat bottoms should be avoided. A large opening in the tank top is necessary for easy filling, cleaning, and inspection. The opening should be fitted with a screen to trap material which would clog sprayer lines. The tank must be fitted with a drain hole at the bottom for draining and cleaning.

Size: The size of the spray tank will depend on spray output needed, boom length, size of the fields to be sprayed, and weight the tractor can handle. Sprayers with a boom 15 metres (50 feet) or wider should have a minimum tank size of 1,400 litres. The tank should have an accurate gauge so that the tractor driver can read the level of liquid remaining in the tank.

Agitators

Agitation in the spray tank is required to ensure spray is uniformly mixed. Vigorous agitation is important when adding pesticide to make up a spray mix. Continuous agitation is also required to keep the spray mixed when using wettable powders or other pesticides containing suspended particles. If there is little agitation, the pesticide may settle to the tank bottom and be applied at the wrong dilution too strong at first, too weak later on.


propellors or paddle wheels
Mechanical agitator
Tank
Jet Agitator Nozzle
Outflow
Inflow from tank
Jet agitator
from pump
sparger
Sparge tube agitator

There are three main types of agitators:

- **Mechanical agitators are paddle wheels or propellers driven by electric motors or by a shaft powered by the tractor. Mechanical agitators provide the most thorough mixing but are expensive and require frequent maintenance.**

- **Jet agitators are special nozzles positioned at the bottom of the tank and connected to a line from the pump. Some of the pump output is returned to the tank through these nozzles. Various sizes of jet agitators are available for different sizes and shapes of tanks. Jet agitators must never be connected to the return line from the pressure regulator valve as this will cause irregular valve operation.**

- **Sparge tubes consist of a perforated pipe or pipes running along the bottom of the tank. This pipe is connected to a pressure line and liquid running through it sweeps the bottom of the tank. These agitators must not be connected to the return line from the pressure regulator valve since this causes irregular valve operation. Sparge tubes are not usually as effective as jet agitators.**

Pumps

A sprayer pump must have sufficient pumping capacity to maintain the desired pressure and supply the needed volume to the nozzles and agitator.

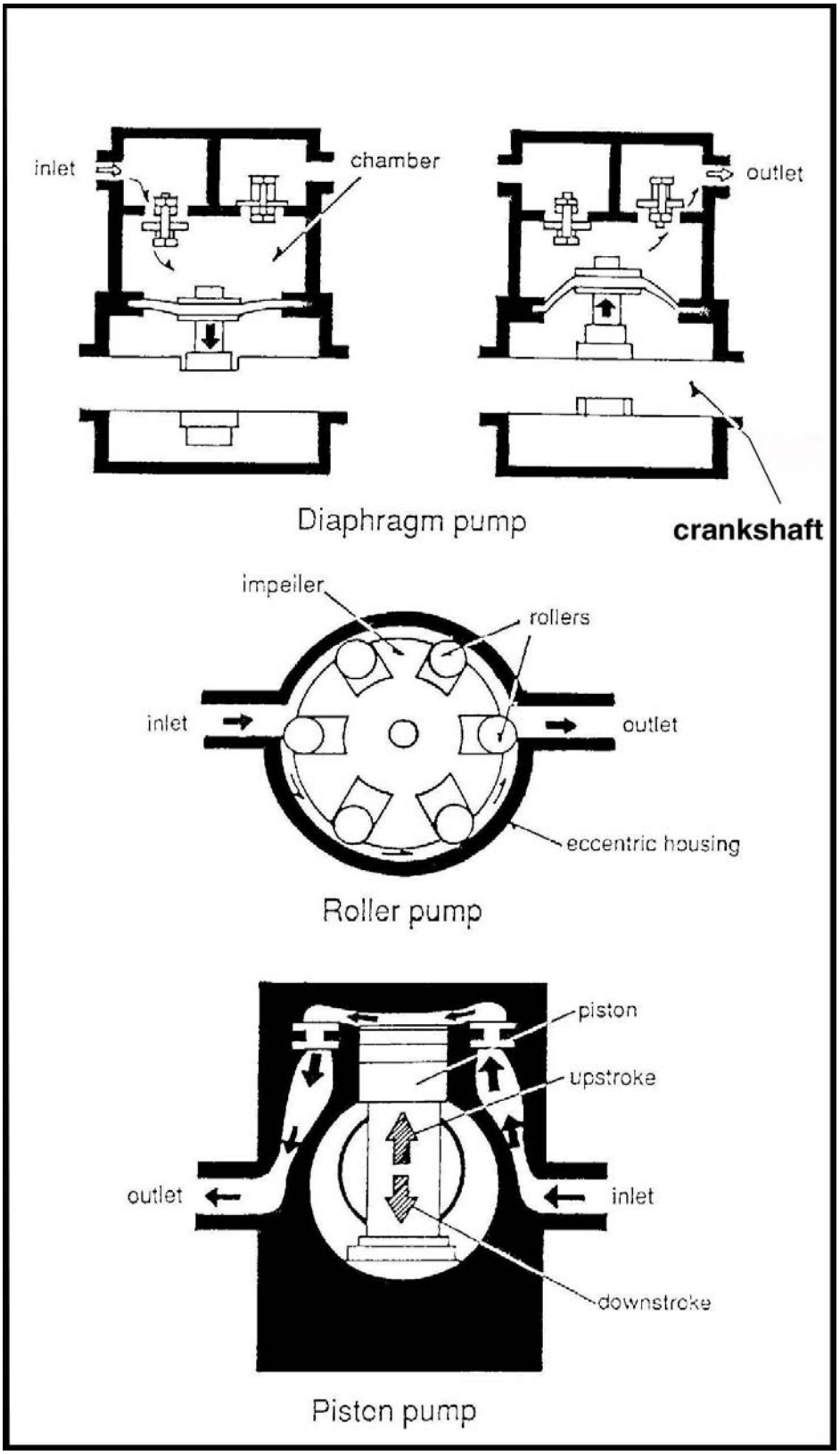
When selecting a pump, the required capacity in litres per minute is determined by the following:

- **highest spray volume applied (litres/acre or litres/hectare)**
- **width sprayed by the boom**
- **speed travelled**
- **size of spray tank (for agitator requirements)**

Parts dealers use tables showing the pump capacity required for combinations of these factors. For example, with a travelling speed of ten kilometres per hour, a boom width of 15 metres, an 1,800 litre tank, and spray volume of 400 litres per hectare (35 litres per acre), the recommended pump capacity is 65 litres per minute.

Pump capacity of new pumps should be 25 percent larger than the required capacity to allow for eventual wear.

In addition to pump capacity, you must consider the operating pressure. Be sure the pump is rated for the pressures you require for your spray operations (see section on nozzle droplet size and pressure). You should not exceed the pressures or operating speeds recommended by the pump manufacturer.


inlet
chamber
outlet
Diaphragm pump
crankshaft
impeiler
rollers
inlet
outlet
eccentric housing
Roller pump
piston
upstroke
outlet
inlet
downstroke
Piston pump

The following are the main types of pumps used in hydraulic sprayers:

- **Diaphragm pumps are available in a variety of pressure and output capacities. They can be adapted for high volume, high pressure sprayers. These pumps are resistant to wear from abrasive solutions such as wettable powders. They operate efficiently at 540 rpm (the usual rate for a tractor power takeoff) and require less horsepower than other pumps with similar flow.**

- **Roller pumps are commonly used due to low cost and compact size. They operate at 540 and 1,000 rpm. Some can be used for moderately high pressure (2,000 kPa; 300 psi) and moderate spray volumes (100 to 300 litres/hectare). The rollers wear rapidly when used for wettable powders.**

- **Piston pumps are primarily designed for high pressure spraying (over 4,000 kPa or 600 psi). Their output is proportional to speed, not the pressure they operate at. They are not commonly used on field sprayers because of their high purchase price. However, they are one of the best pumps for custom applicators.**

Hoses

Hoses carry spray mixture from the tank to the nozzles. The pressure in these hoses will vary at different locations in the sprayer.

Suction hoses drawing spray mixture from the tank should be wire reinforced to prevent collapse. The diameter of suction hoses must be at least as large as the pump inlet hole.

Hoses on the pressure side of the pump must be able to handle higher pressures than normal operations use in order to avoid bursting from pressure surges. To avoid pressure loss between the pump and the nozzles, use hoses of recommended size, keep the lengths as short as possible, and have as few restrictions (fittings, elbows, or sharp bends) as possible.

Filters and Strainers

Filters are required on sprayers to minimize wear on pumps, pressure regulators, and nozzles. They also help prevent nozzle plugging.

Filters are referred to by their mesh size which is the number of holes per linear inch (25 mm). The larger the number, the smaller the holes.

When using most pesticides, an 80 or 100 mesh basket strainer should be used in the tank filler opening. For wettable powders a 50 mesh strainer is used. These strainers keep most unwanted particles out of the spray tank.

Additional filtration is required to help prevent particles from entering the pump. An in-line filter is located between the tank and pump when using diaphragm, roller, or piston pumps. A 50 mesh size is used for wettable powders and a 50-60 mesh size is used for other pesticides.

In order to help prevent nozzle plugging, screens or strainers are recommended in nozzle tips. Again, a 50 mesh size is used with wettable powders or for large tips. An 80 or 100 mesh strainer is used with other pesticides and for small tips.

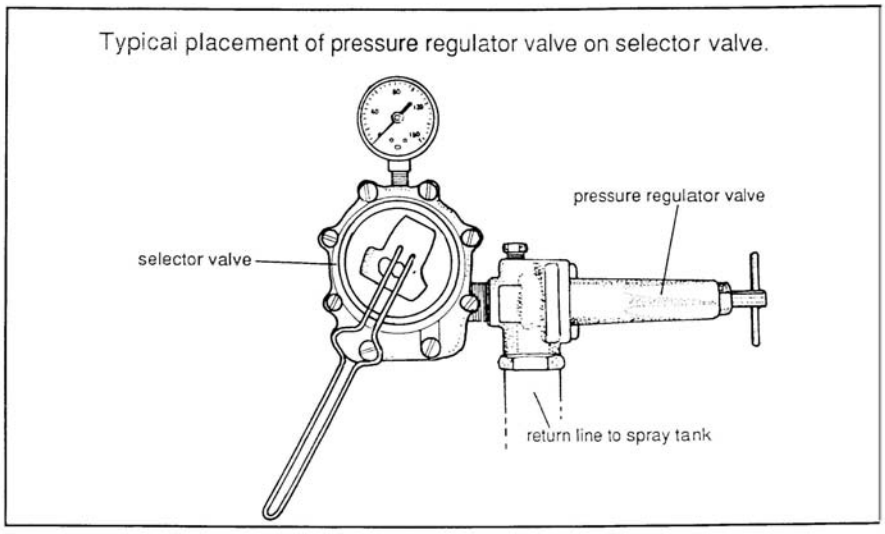
Always check whether there are filtration recommendations on the pesticide label.

Loss of flow or pressure is often the result of clogged filters. Clean the filters at the end of the day's spraying and inspect them before spraying at the beginning of the spray season. Replace damaged ones.

Frequent filter clogging should be solved by drawing water from a cleaner source. Don't remove filters - they're just doing their job protecting your nozzles from clogging.

Pressure Regulator Valves

The pressure regulator valve controls the operating pressure which affects the output of spray, spray pattern, and droplet size produced by the nozzles. There are two main types of pressure regulators: relief valves and unloader valves.



Relief valves can be adjusted to regulate sprayer pressure by opening at the desired setting. When the valve is open, part of the flow from the pump is returned to the tank via the by-pass line. Usually the valve is always partly open while the sprayer is operating.

Unloader valves are used on sprayers operated at pressures over 1,400 kPa (200 psi). These valves unload the pressure to the pump when the flow to the nozzles is shut off. Each time the nozzles are shut off, there is a pressure surge in the lines. The pressure surge triggers the unloader valve and the spray returns to the tank under low pressure. This reduces pump wear as well as relieving pressure in the lines.

Pressure Gauges

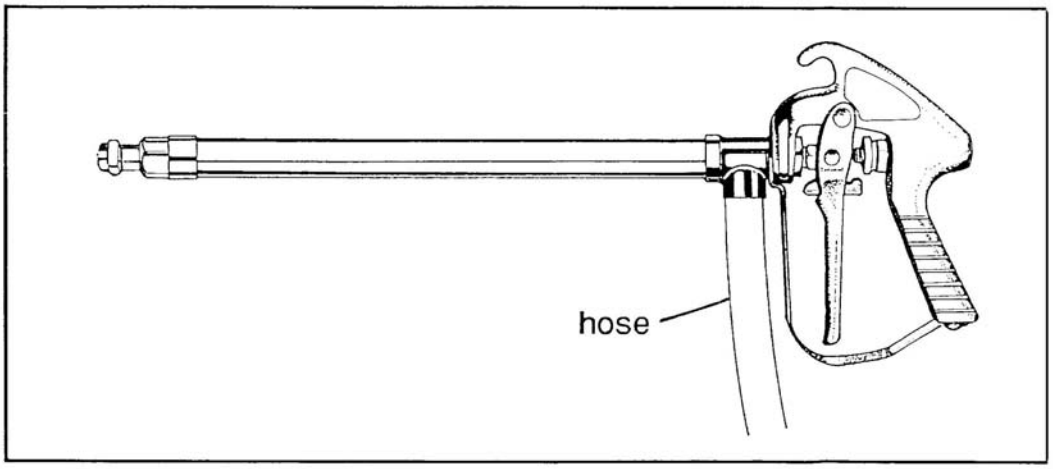
Pressure gauges are used to ensure that pressure to the nozzles has been correctly adjusted. Ideally, sprayer pressure should be measured at the boom near the nozzles. However, most sprayers have the gauge located on the selector valve.

Use a spare gauge to compare pressure on the boom with that on the selector valve. A considerable loss in pressure can occur between the pump and the nozzles on some sprayers. It is important that the desired pressure is obtained at the nozzles to prevent distortion of spray pattern or incorrect droplet size.

A pressure gauge should have a total range of twice the required operating pressure. The gauge should be glycerine- or oil-filled to dampen pump pulsations which make reading the gauge difficult. Gauges should be checked yearly for accuracy. A spare, accurate gauge should be kept on hand in case of failure and for checking pressure at the boom.

Spray Guns (Handgun)

A spray gun is a sprayer which you direct at the desired target. It is attached to the sprayer by a hose (usually ten metres or longer). Spray guns may be used for spot treatments or to treat weeds, crops, or ground in areas inaccessible to a boom sprayer.



The spray gun has a shutoff trigger or a rotating shutoff handle and a single nozzle. Precise calibration is very difficult so spray guns should be used for applications where accurate rates are not required. For example, herbicides are generally applied with a handgun by mixing a very dilute solution and applying to the point of runoff.

Quiz 8.2 - Boom Sprayer Parts

1. Should you put Roundup in a galvanized steel tank? Why or why not?

_____

2. Which of the three types of agitators mentioned is usually the least effective? Which is the most effective, especially for wettable powders?

_____

_____

3. Which of the three types of pumps mentioned will wear out the fastest when used for wettable powders?

_____

_____

4. Your pump operates at a pressure of 2,000 kPa (300 psi). Would a pump outlet hose able to handle 2,000 kPa be satisfactory? Why or why not?

_____

_____

5. You have two filters - a 50 mesh and a 100 mesh. One has larger openings. Which one would you use with a wettable powder - the one with the larger or smaller openings? Which mesh size would it be?

_____

6. Do pressure regulator valves return part of the pump flow to the tank via a by-pass? Can this be connected to a jet agitator? Why or why not?

_____

_____

7. You use a spare pressure gauge to check pressure at the nozzles. It doesn't show the same reading as the pressure gauge on your selector valve. Which gauge would show the lower reading? Why?

_____

_____

_____

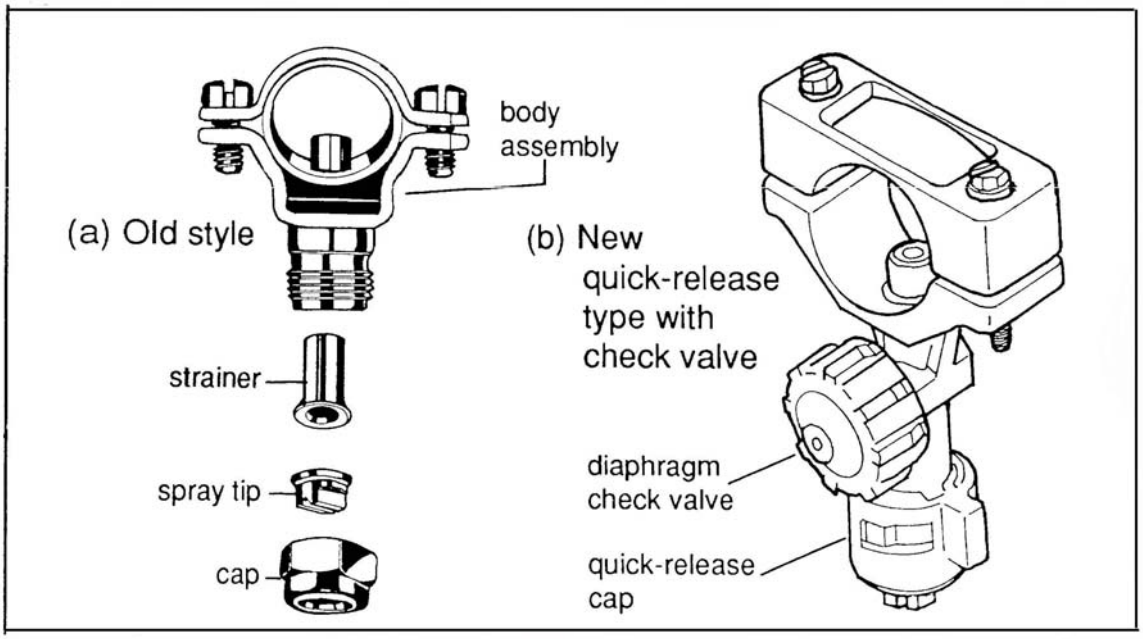
Now check your answers against the Answer Key at the end of the lesson. If most of your answers are right, continue with the next section of Lesson 8. If not, go back and review before continuing.

Nozzles

Nozzle Parts

Sprayer nozzles have three main purposes:

- **breaking liquid into droplets;**
- **spreading the droplets in a specific pattern;**
- **helping regulate sprayer output.**



The older style nozzle has a threaded cap which holds the spray tip and strainer to the nozzle body. The nozzle body is clamped to the boom.

Newer nozzles have a quick-release nozzle cap which requires only a quarter turn to attach or remove it. They can be removed by hand without use of a wrench. This makes it easy to remove tips and strainers for changing and cleaning. The quick-release nozzles also correctly align the nozzle tip each time it is replaced.

Nozzle check valves are recommended to stop spray solution leaking out of nozzles after the flow of spray has been shut off. This prevents release of spray when turning at the end of rows or after you leave the treatment area. The check valves also keep the boom full and provide spray immediately when the flow is turned on again. You must increase boom pressure to compensate for valve opening pressure (typically 35 kPa; 5 psi).

Nozzle Tip Resistance to Wear

Nozzle tips are made from a variety of materials. The most commonly used materials are stainless steel, nylon, and brass. Tips made of hardened stainless steel, ceramic, Alumax, or Kemetal are used where extra long wear is desired.

In tests of nozzles using an abrasive chemical, the wear after 25 hours was rated on a scale of 0 to 24 as follows:

Tip Material	Rating Scale	Amount of Wear
Alumax, Kemetal	0	no wear
Ceramic	1	some wear
Nylon	2	some wear
Stainless steel	4	some wear
Brass	24	rapid wear

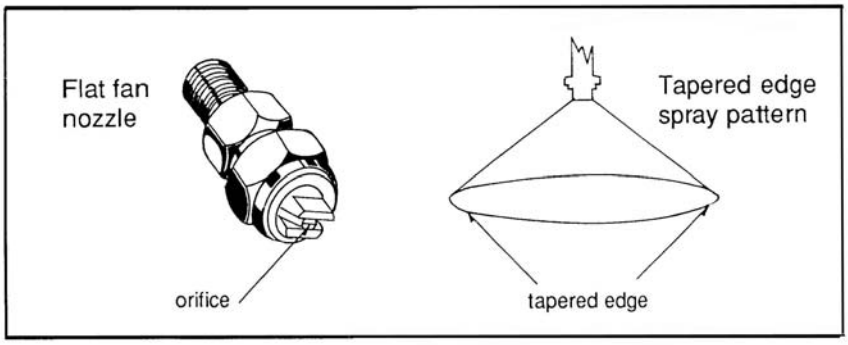
Alumax, Kemetal, and ceramic tips are expensive but are very resistant to wear. Nylon and stainless steel tips will give acceptable wear with most pesticides. Brass tips are less expensive but will wear very quickly and should be checked frequently for spray output and spray pattern.

With worn nozzles the flow rate is increased, the spray pattern is distorted, and uneven application will occur. You can compensate for some wear by recalibrating (measuring spray output), but calibration will not correct an uneven spray pattern. You must replace tips that are excessively worn. A general rule of thumb is that tips should be replaced if their output varies from the manufacturer's specifications by more than 15%.

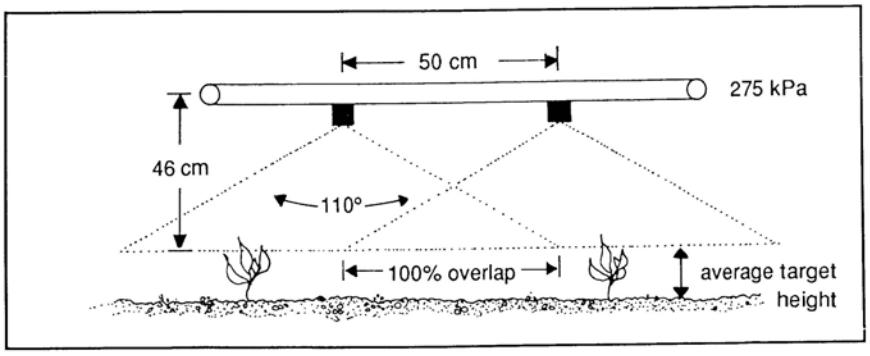
Nozzle tips can easily be damaged when being cleaned. Flat fan spray tips have finely machined edges around the opening to control the spray. Even the slightest damage from improper cleaning can distort the spray pattern. If a tip does plug, use only a soft-bristled brush or, very gently, a toothpick.

Nozzle Spray Patterns

There are four main types of boom nozzle tips which are named by their spray pattern: tapered flat fan, even flat fan, hollow cone, and solid cone.

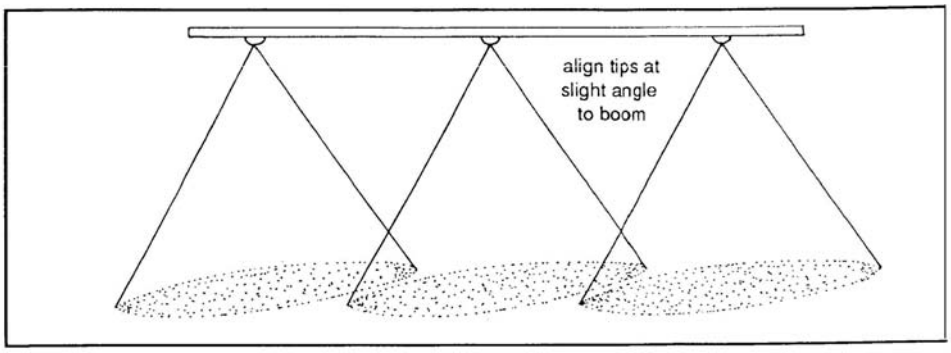


Tapered flat fan nozzle tips are best for broadcast spraying. These tips produce more spray at the centre than at the edge of the pattern. By properly overlapping adjacent nozzle spray patterns, a uniform broadcast application is obtained across the boom. These nozzles are made to produce several different spray angles (for example, 60°, 80°, or 110°). Recently there has been a trend to use the wide angle nozzles (110°) and to completely overlap adjacent spray patterns. This overlap results in a more uniform spray even if boom height varies due to an uneven field or crop or weed height differences.

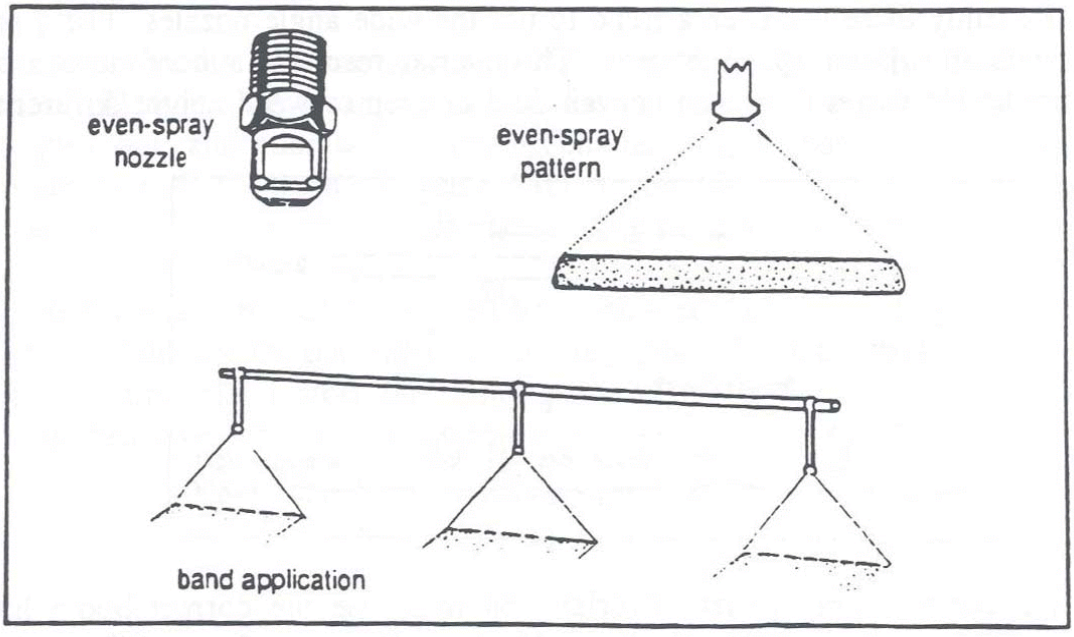


To obtain the correct spray pattern overlap you must use the correct boom height. Recommended heights for each nozzle (e.g., 45 cm or 18 inches for an 80^0 nozzle) are based on specific pressures (e.g., 275 kPa; 40 psi) and nozzle spacing (e.g., 50 cm; 20 inches). Increasing pressure will produce a wider spray angle which will require adjusting the boom height to obtain the correct overlap.

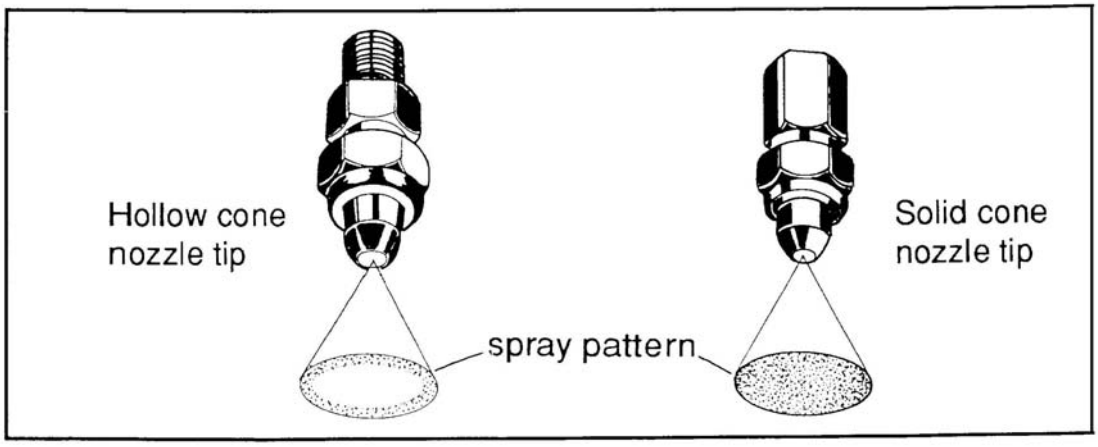
Tapered flat fan tips should be aligned at a slight angle to the boom so the spray patterns do not strike each other where they overlap. Otherwise, spray in the area of overlap would be disrupted. New quick-release nozzles automatically offset the tips by a few degrees.



Even flat fan tips are used for band spraying when there is no overlap of adjacent nozzle patterns. These tips produce an even spray pattern across their width. The width of the band sprayed can be controlled by adjusting the nozzle height above the target.



Hollow cone nozzle tips are used when low volume applications of fine droplets are required for thorough coverage. Solid cone nozzle tips are best suited for high volume applications where dense foliage requires a penetrating spray.



Both hollow cone and solid cone tips are used primarily for spraying insecticides and fungicides in row crops. They are best operated at high pressure (550 kPa or greater) and are often used on drop pipes from a row crop boom.

Selecting Nozzles for Their Output

The spray volume to be applied per hectare or per acre is usually given on pesticide labels or in Crop Production Guides. An example of a typical instruction might be "use 2.5 kg of pesticide in 300 litres of water per hectare." In this example the spray volume is 300 litres per hectare.

If spray volume is not specified you can use generally-accepted levels. For most herbicides use 300 to 500 L/hectare (120 to 200 L/acre). For herbicides on cereal and oilseed crops use 45 to 200 L/hectare (18 to 80 L/acre). For fungicides and insecticides use 100 to 1,000 L/hectare (40 to 400 L/acre).

Considerations in selecting output are:

- **Larger spray volumes are an advantage because you can obtain good coverage with coarse sprays which are less likely to drift.**
- **Larger spray volumes are a disadvantage because more mixing is required.**

In order to obtain the desired spray volume you must select the right combination of the following:

- **nozzle tip**
- **nozzle spacing**
- **pressure at the boom**
- **forward speed of the sprayer**

Nozzle manufacturers help applicators choose the right nozzle tips by providing charts on tip performance. Such charts show the nozzle tip that will produce a certain spray volume for a given nozzle spacing, pressure, and forward speed.

For example, in the nozzle tip performance chart that follows (for 110° spray nozzles), you would select nozzle number 11004 to obtain a spray volume of 80 litres/acre using 50 cm spacing, a pressure of 200 kPa and a ground-speed of 8 km/h.

Flat Fan Nozzle Tip Output Chart
(Based on spraying Water and 50 cm nozzle spacing) **110^0 Spray Angle**

Nozzle Tip	Pressure kPa	Output in Liters Per Minute	Spray Volume in Liters Per Acre at Various Speeds						
			6km/h	7km/h	8km/h	9km/h	10km/h	11km/h	12km/h
11001	200	.32	26	22	20	17	16	14	13
	275	.38	30	26	23	20	18	16	15
	300	.39	32	27	24	21	19	17	16
110015	200	.48	39	33	29	26	23	21	20
	275	.57	46	39	35	31	28	25	23
	300	.59	48	41	36	32	29	26	24
11002	200	.65	53	44	40	34	32	28	26
	275	.76	62	52	46	40	36	32	30
	300	.79	64	54	48	42	38	34	32
11003	200	.97	79	68	59	53	47	43	40
	275	1.15	93	80	70	62	56	51	47
	300	1.18	96	82	72	64	58	52	48
11004	200	1.30	105	88	80	68	64	56	52
	275	1.52	123	104	92	80	72	64	60
	300	1.58	128	108	96	84	76	68	64
11005	200	1.61	130	111	96	87	78	71	65
	275	1.89	153	131	114	102	92	83	77
	300	1.97	159	136	119	106	95	88	80
11006	200	1.93	158	136	118	106	94	86	80
	275	2.30	185	160	140	122	112	102	94
	300	2.37	191	164	144	128	116	104	96
11008	200	2.58	209	176	160	136	128	112	104
	275	3.04	246	208	184	160	144	128	120
	300	3.16	255	216	192	168	152	136	128
11010	200	3.22	261	222	192	174	156	142	130
	275	3.78	306	262	228	204	184	166	144
	300	3.95	320	272	238	212	190	176	160

Sometimes the output of a nozzle tip will vary from that specified by the manufacturer. Therefore, it is very important to determine the actual output of your sprayer under typical operating conditions. This procedure (sprayer calibration) is described in Lesson 9.

Nozzle Spray Droplet Size

The size of spray droplets can vary greatly. Droplets are categorized based on their size and typical use as shown below:

Typical droplet sizes for various types of pesticide applications

Type of Spray	Average Droplet Size of Micron	Examples of Uses
Fog	**0.1 - 5.0**	**Greenhouse foggers**
Fine mist	**5.0 - 50**	**greenhouse misters**
Coarse mist	**50 - 100**	**air-blast and high pressure boom sprays of insecticides or fungicides**
Fine spray	**100 - 250**	**typical insecticide or fungicide sprays**
Medium spray	**250 - 500**	**typical flat fan nozzle herbicide sprays**
Coarse spray	**500 - 700**	**low pressure flat fan nozzle herbicide sprays**
Very Coarse spray	**700 - 1000**	**large droplet flooding fan and raindrop nozzle sprays for soil applied herbicides**

Very small droplets are typically used in greenhouse misting or fogging operations. They are tiny enough to remain suspended in the air for long periods.

Fine sprays are used for field spray applications of insecticides and fungicides. A fine spray is able to penetrate the foliage and provide good coverage of plant surfaces.

Medium sprays are often used for post-emergence application of herbicides. If droplets are too small (less than 100 microns) there is a danger of pesticide drift. If the droplets are too large (greater than 650 microns) they are likely to bounce off plant surfaces and provide incomplete coverage.

Coarse sprays can be used for soil treatments such as applying pre-plant or pre-emergence herbicides or some drenches.

Changing Droplet Size

Droplet size is changed by nozzle opening size, spray angle, and pressure.

- **Opening size: nozzles with a larger tip opening produce larger spray droplets than nozzles with a small tip opening.**

- **Spray angle: nozzles which produce a wide spray angle (e.g., 110°) produce smaller spray droplets than nozzles with a narrow spray angle (e.g., 60°) if they both have the same spray output.**

- **Pressure: as line pressure increases, the size of spray droplets will become smaller.**

Herbicides are generally applied at low pressures (200 to 275 kPa) to reduce spray drift. Insecticides and fungicides are often applied at higher pressures (500 to 2,000 kPa) so the smaller droplets will penetrate the leaf canopy and provide good leaf coverage.

Using Nozzles to Control Spray Drift

Spray drift is the movement of pesticide spray droplets away from the target. As described in Lesson 7, drift can result in damage to nearby crops or may contaminate water and may be a hazard to pollinating insects, to animals, and to humans. Drift also means that less pesticide is being applied to the target; excessive drift can reduce the effectiveness of a treatment.

Spray drift is affected by three main factors:

- **wind speed**
- **droplet size**
- **height of nozzle above target (distance travelled by droplet)**

The most obvious and effective way to reduce spray drift is to spray when the winds are light. You can also select and adjust equipment to minimize drift as follows:

1. **The use of larger nozzle tip openings, producing larger spray volumes, is recommended for drift control. The larger the tip opening, the larger the droplets. However, if droplets are too large, plant surface coverage will be poor. A careful balance must be struck between controlling drift and providing adequate coverage.**

   Example: "Raindrop" and similar tips provide mostly large droplets with very few droplets small enough to drift. However these tips should only be used where uniform coverage is not critical.

2. **Another way of reducing drift is using lower line pressure which produces larger droplets. However, a large reduction in pressure is needed to significantly alter droplet size. Nozzles must be operated within the pressure range recommended by the manufacturer or the spray pattern will be affected. For some applications, nozzles are available which operate at a low pressure range (75 to 250 kPa) and provide an acceptable spray pattern.**

3. **Reducing the height of the nozzles above the target will also help reduce drift. The distance from nozzle to target affects the time required to reach the target. During this time the spray droplets can be affected by wind. (This principle also applies to sprays directed sideways.)**

You can reduce the height of nozzles by selecting those with a wide spray angle (e.g., 80° or 110°). Wider angle nozzles can be used closer to the target surface than smaller angle nozzles (e.g., 60°).

Quiz 8.3 - Nozzles

1. What are the three main purposes of nozzles?

_____

_____

2. You're deciding between buying brass nozzles or more expensive stainless steel-tipped or nylon-tipped nozzles. What other costs should you consider?

_____

_____

3. Match the following nozzle tips with the job they're most suited for.

tapered flat fan ___	**a) high volume on dense foliage**
even flat fan ___	**b) uniform broadcast with overlap**
solid cone ___	**c) low volume of fine droplets**
hollow cone ___	**d) band spraying with even spray across band**

4. What are typical outputs (spray volumes) for most boom spray applications of:

herbicides:

fungicides:

5. Correct output (spray volume) of a boom sprayer results from the right combination of which four equipment factors?

_____

_____

6. Herbicides are generally applied at low pressures, whereas insecticides and fungicides are often applied at higher pressures. Why?

_____

_____

7. What are the three main factors affecting spray drift?

_____

_____

8. Which nozzle opening size (large or small), nozzle spray angle (wide or narrow), and pressure (high or low) would give you the smallest droplet size? Which would give you the largest droplet size?

	smallest droplet	**largest droplet**
nozzle opening size	_____	
nozzle spray angle	_____	
pressure	_____	

Now check your answers against the Answer Key at the end of the lesson. If you've done well, continue with Lesson 8. If not, review those sections that gave you trouble before proceeding any further.

Cleaning Spray Equipment

Application Equipment

The decontamination of tanks, booms, and nozzles is often overlooked. Nonetheless, it is very important. Many operators fail to decontaminate this equipment at the end of the working day, at the end of the application season or when pesticide changes are made. This area of maintenance should not be overlooked - many cases of poisoning have occurred from equipment which has not been properly decontaminated. Furthermore, herbicide residues in the spray tank may cause severe damage to subsequently treated susceptible crops.

The simplest way to reduce the hazards of contaminated equipment is to dilute the pesticide with lots of water. When water-based sprays have been used, several washes using a small volume (e.g., up to 10% of the spray-tank capacity) are better than merely filling the spray tank once with clean water. Cleaning can be improved by using a 0.2 per cent suspension of activated charcoal. If there are no brass components, a dilute solution of household ammonia (10 mL ammonia/5 L water) is also useful as a cleaning agent. On motorized equipment, the volume of water must be sufficient to enable the agitation system to operate, so that the tank is completely rinsed. The final rinse should be with fresh water. Use caution when disposing of rinse solutions to avoid contamination of water sources.

A sprayer should be cleaned:

- **before you first use it**
- **after each day's use**
- **when changing pesticides**
- **before storage after the spray season is over**

New sprayers may contain metallic chips and dirt from the manufacturing process. Remove the nozzles; flush the sprayer with clean water. Clean all strainers and nozzles.

After each day's use, flush clean water through the sprayer tank, pump, and hoses. Clean the filter, strainers, and nozzles. Drain the tank and allow it to dry. Use a toothbrush or other soft material to clean nozzle tips.

Before use of a different pesticide or before off-season storage, a sprayer should be thoroughly cleaned to prevent contamination or corrosion. For thorough removal of most pesticides, the following procedure is recommended:

1. **Choose your cleaning area carefully. Make sure that discharged cleaning water will not contaminate wells, streams, or crops.**

2. **Put on protective clothing appropriate for the pesticide you are cleaning (at least wear waterproof gloves and boots).**

3. **Wash the outside of sprayer with soapy water and rinse with clean water. Compacted pesticide deposits can be removed with a stiffbristle brush.**

4. **Rinse out the spray system with fresh water. Hose down the inside of the tank and partly fill it with water. Circulate the water through the sprayer and out through the nozzles. Drain the water from the tank, hoses, boom, pump, and filters.**

5. **Remove nozzles and strainers and clean (e.g., in a detergent solution).**

6. **Fill the tank with fresh water, circulate through the system, and again drain the sprayer completely.**

7. **Fill the tank with water and for each 100 litres of water add one of the following:**

    - **one litre of household ammonia**
      or
    - **500 grams of washing soda, lye, or Nutrasol**

If you only partly fill the tank with cleaning solution, you will have to find a way to rinse the entire inside of the tank. One method is to rock the spray tank.

8. **Circulate the solution so it contacts all internal parts of the sprayer and pump out a small amount through nozzle outlets (the nozzles are removed). Leave most of the solution in the system overnight.**

9. **The next day, recirculate the entire system, then drain it completely.**

10. Rinse out twice with clean water, recirculating and draining each time. Before winter storage, remember to drain the pump, boom, and all lines to prevent frost damage. Add light oil or antifreeze during the last rinsing to leave a protective coating on all parts.

Special Cleaning Situations

Some pesticides have specific cleaning instructions. Check the label to see if there are cleaning recommendations.

Most pesticides degrade in alkaline or acid media. And this fact forms the basis of cleanup procedures. Of the three main pesticide groups, organophosphorus compounds are more readily degradable than carbamate or chlorinated hydrocarbon compounds.

Organophosphorus Compounds: A strong solution of washing soda and bleach run through the system will remove organophosphorus residues. Afterwards, rinse at least twice with clean water.

Carbamate Compounds: A solution of washing soda, or a strong soap solution may be used to remove pesticides such as carbaryl, aminocarb and methomyl. Clean water should be used as the final rinse.

Chlorinated Hydrocarbon Compounds: Equipment contaminated with these compounds cannot be detoxified effectively using water and detergent or caustic soda. The chemical supplier will be able to supply specific directions regarding the best decontamination procedure. Chemicals frequently recommended for decontamination are household ammonia, washing soda, or activated charcoal. Some equipment may be subject to corrosion if exposed to strong alkali or acid. Rinse thoroughly as soon as possible and run lots of clean water through the lines and nozzles. Soap and water is effective for removing methoxychlor.

Chlorophenoxy Compounds: Herbicides such as 2,4-D should be flushed completely from the system to prevent contamination of the next charge of spray and, therefore, damage to crops. However, complete decontamination is generally considered impossible for these compounds. If the same equipment must be used for the application of other pesticides, the following decontamination methods are offered.

For either oil- or water-soluble chlorophenoxy compound solutions, add 30 g activated charcoal and 30 g detergent to each 10 L water. Shake well and discharge through the nozzles. OR add 300 g lye to each 10 L water and allow to stand for at least two hours., Then discharge through the nozzles and rinse the system twice with clean water.

For water-soluble solutions only, add 50 g washing soda to each 10 L water. Allow to stand for at least two hours. Then discharge and rinse the system twice with clean water. OR add 125 mL household ammonia to each 10 L water. Flush some through the nozzles and leave the rest in the tank overnight. Then discharge and thoroughly rinse the system with clean water.

For oil-soluble formulations only, add 375 mL kerosene, 50 g washing soda, and a little detergent to each 10 L water. Allow to stand for at least two hours. Then discharge and rinse the system twice with clean water.

Rubber and synthetic seals, connections, and even hoses should be periodically discarded. They tend to retain some pesticide deposits which are very difficult to remove, and they may deteriorate if left installed during a long period without use. These items should, therefore, be renewed at least at the beginning of each season. Since they tend to adsorb pesticides, seals should be renewed before changing pesticides if the previous pesticide would be harmful to the next crop to be treated.

At the end of the season, individual components of application equipment should be thoroughly decontaminated and dried before being stored. They can be put in plastic bags or wrapped in plastic sheeting with silica gel to absorb any moisture.

Quiz 8.4 - Cleaning Spray Equipment

1. When should you clean your sprayer? (hint - four types of occasions)

_____

_____

_____

_____

2. After rinsing with water, what solution can be used to clean a spray tank?

_____

_____

3. How many times during cleaning do you rinse the spray system with fresh water for thorough removal of most pesticides? Which steps do you rinse after?

_____

_____

4. What should be added to the final rinse before winter storage? Why?

_____

5. Separate equipment or hoses are recommended for applying 2,4-D and similar hormone-type herbicides. Why?

_____

Now check your answers against the Answer Key at the end of the lesson. If most of your answers are right you're ready to move on to Lesson 9. If not, go back and review the material and try again.

Looking Ahead

In Lesson 8 you have learned about different types of application equipment. Lesson 9 explains how to calibrate this equipment to ensure the correct application of pesticides.

Answer Key

Quiz 8.1 - Types of Application Equipment

1. Of the two hand-operated sprayers mentioned (hand-held and back-pack), which can give you the most even spray coverage? Why?

A back-pack, because you can keep pumping the hand lever and maintain a constant pressure through the nozzle.

2. Spray booms longer than nine metres (30 feet) need extra support, such as outrigger wheels, to stop them from bouncing. Why?

Bouncing makes the spray pattern uneven as the boom height changes.

3. What is another common cause of bouncing spray booms?

too high a forward speed

4. What is the major difference between broadcast and band treatments?

Broadcast applies an even treatment over an area, whereas band only treats bands (or strips) and leaves untreated areas between them.

5. What are two reasons granules should be incorporated during or immediately after application?

so birds won't eat them and to activate the pesticide

6. What three weather conditions can cause problems for the small droplets from air-blast sprayers? What are those problems?

Wind will cause drift of the smaller droplets.
High temperature will evaporate the smaller droplets.
Low humidity will help evaporate the smaller droplets.

7. Which produces larger droplets - a mister or a fogger?

a mister

8. What is the difference between a cold fogger and a thermal fogger?

Cold foggers produce fog-sized droplets with a spinning disc or with fine nozzles under high pressure.
Thermal foggers use heat to evaporate an oil solution of the pesticide which condenses into fine droplets as it cools, forming a fog.

9. A greenhouse is about to be smoke fumigated with three smoke bombs in each of two aisles. What is the minimum number of people needed to ignite them? Which of the three bombs in each aisle do they ignite first?

At least two people are needed, one in each aisle. They would each ignite the bomb furthest from the exit, moving towards the exit as they ignited the other bombs.

Quiz 8.2 - Boom Sprayer Parts

1. Should you put Round-up in a galvanized steel tank? Why or why not?

No, because it can cause a chemical reaction.

2. Which of the three types of agitators mentioned is usually the least effective? Which is the most effective, especially for wettable powders?

Sparge tubes. They are less effective than jets. Mechanical agitators are best, especially for wettable powders.

3. Which of the three types of pumps mentioned will wear out the fastest when used for wettable powders?

Roller pumps.

4. Your pump operates at a pressure of 2,000 kPa (300 psi). Would a pump outlet hose able to handle 2,000 kPa be satisfactory? Why or why not?

No, because occasional pressure surges will be greater than that.

5. You have two filters a 50 mesh and a 100 mesh. One has larger openings. Which one would you use with a wettable powder the one with the larger or smaller openings? Which mesh size would it be?

larger openings; 50 mesh

6. Do pressure regulator valves return part of the pump flow to the tank via a by-pass? Can this be connected to a jet agitator? Why or why not?

Yes, they do. No, because it would result in irregular valve operation.

7. You use a spare pressure gauge to check pressure at the nozzles. It doesn't show the same reading as the pressure gauge on your selector valve. Which gauge would show the lower reading? Why?

The lower reading would be at the nozzles. There is a loss of pressure between the pump and nozzles because of resistance (fluid friction) in the connecting hoses and pipes

Quiz 8.3 - Nozzles

1. What are the three main purposes of nozzles?

Breaking liquids into droplets.
Spreading droplets in a specific pattern.
Regulating sprayer output.

2. You're deciding between buying brass nozzles or more expensive steel-tipped or nylon-tipped nozzles. What other costs should you consider?

Replacing worn ones earlier.
Time spent checking wear and recalibrating.

3. Match the following nozzle tips with the job they're most suited for.

tapered flat fan	**b) uniform broadcast with overlap**
even flat fan	**d) band spraying with even spray across band**
solid cone	**a) high volume on dense foliage**
hollow cone	**c) low volume of fine droplets**

4. What are typical outputs (spray volumes) for most boom spray applications of:

herbicides: 300 - 500 L/ha (120 - 200 L/acre)
fungicides: 100 - 1,000 L/ha (40 - 400 L/acre)

5. Correct output (spray volume) of a boom sprayer results from the right combination of which four equipment factors?

nozzle tip, nozzle spacing, pressure at boom, forward speed of sprayer

6. Herbicides are generally applied at low pressures, whereas insecticides and fungicides are often applied at higher pressures. Why?

Herbicides use low pressures to keep drift to a minimum.
Insecticides and fungicides are often applied at higher pressures in order to better penetrate the leaf canopy and cover leaf surfaces.

7. What are the three main factors affecting spray drift?

wind speed, droplet size, and height of nozzle above target

8. Which nozzle opening size (large or small), nozzle spray angle (wide or narrow), and pressure (high or low) would give you the smallest droplet size? Which would give you the largest droplet size?

	smallest droplet	largest droplet
nozzle opening size	small opening	large opening
nozzle spray angle	wide angle	narrow angle
pressure	high pressure	low pressure

Quiz 8.4 - Cleaning Spray Equipment

1. When should you clean your sprayer? (hint - four types of occasions)

1. before you first use it
2. after each day's use
3. when changing pesticides
4. before storage after the spray season

2. After rinsing with water, what solution can be used to clean a spray tank?

100 L water with 1 L ammonia or 500 g washing soda, lye, or Nutrasol

3. How many times during cleaning do you rinse the spray system with fresh water for thorough removal of most pesticides? Which steps do you rinse after?

four times
1. after washing and rinsing outside of sprayer
2. after removing and cleaning nozzles and filters
3. and 4. twice after leaving cleaning solution in overnight and draining it

4. What should be added to the final rinse before winter storage? Why?

light oil or antifreeze as a protective coating

5. Separate equipment or hoses are recommended for applying 2,4-D and similar hormone-type herbicides. Why?

These pesticides cannot be completely washed out of the hose lines.