Chapter 6.
Herbicide Application Equipment for Rights-of-Way Vegetation Management

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Important Terms

backpack sprayer	granule applicators	Raindrop
Boom Buster nozzle	handgun	regular flat fan nozzle
boomless spraying	hollow cone pattern	straight stream nozzle
Directa-Spra	off-center nozzle	whirl-chamber nozzle
flooding flat fan	Radiarc	

Herbicide applications are usually made in a liquid form. Dry formulations are used in limited situations. All liquid spray equipment have unique advantages and disadvantages. Most are usually operated at low pressures, less than 40 psi at the spray tip.

BROADCAST LIQUID APPLICATION

Sprayers are often equipped with booms containing a row of similar nozzles. These boom sprayers are used for broadcast applications of herbicides. The nozzles break the spray solution into small drops and distribute the spray in a specific pattern. Nozzle performance depends on nozzle design or type, operating pressure, size of the opening, discharge angle, speed, and distance of nozzle from the target.

Nozzles are made up of the nozzle body, cap, strainer (screen), and tip or orifice. The nozzle body holds the strainer and tip in proper position. Several types of tips, that produce a variety of spray patterns, may be interchanged on a single nozzle body made by the same manufacturer. The cap is used to secure the strainer and the tip to the body. Some nozzle bodies are equipped with check valves built into the nozzle body to prevent dripping.

Boom with Conventional Tips

Regular Flat Fan

The regular flat fan (Figure 1) is the most commonly used nozzle for boom application of liquid sprays. The regular flat fan tip makes a narrow oval pattern with tapered edges. It is used for broadcast applications at 15 - 40 psi. The spray pattern that emerges from the nozzles requires an overlap of 30-50% for even distribution. To make a uniform application with these nozzles on a boom the nozzles should be evenly spaced, have the same fan angle, and the boom must remain at a constant height, parallel with the ground. Spacing on the boom, spray angle, and boom height determine proper overlap and should be carefully controlled. Fan spray angle is the angle between the edges of the spray pattern. Tips are available with fan spray angles of 25, 50, 65, 73, 80, and 110 degrees. The nozzles are usually spaced 12 - 20 inches apart on the boom. The required height of the boom above the ground varies with fan angle. Closer or wider spacing is possible and is compensated for by adjusting boom height.

Figure 1. Regular flat fan nozzles used to treat railroad ballast.

Flooding Flat Fan Nozzle

A flooding flat fan nozzle delivers a wide-angle flat spray pattern, 115-125 degrees. It also operates at low pressure and produces large spray droplets (Figure 2). Droplet distribution is fairly uniform across the pattern, but is not as even as the pattern of a regular flat fan nozzle. Tips should be tilted 45 degrees for broadcast spraying. The recommended nozzle spacing is 40 inches. These nozzles should have 100% overlap so the width of the spray pattern on the ground is twice as wide as the nozzle spacing. Boom height should be adjusted until this overlap is achieved.

Figure 2. Widely spaced flood tips with 100%

Whirl-Chamber Nozzle

The side-entry hollow cone or "whirl-chamber" nozzle produces a very wide angle, hollow cone spray pattern at very low pressures (Figure 3). It has a large opening and resists clogging. Because of

Figure 3. Side-entry hollow cone nozzles should be angled to the rear rather than pointing straight down.

the wide spray angle, the boom can be operated close to the ground, thus reducing drift. Spacing for double coverage and angling 15 to 45 degrees to the rear is recommended for uniform application.

Figure 4. The Rain Drop® was one of the first nozzles designed for reducing spray drift.

Rain Drop®

The Rain Drop nozzle produces a hollow-cone pattern and large droplets for drift control. Although the pattern is similar to the whirl-chamber tip, this nozzle contains a secondary chamber where the swirling action of the spray solution further reduces small droplets (Figure 4). The spray angle varies from 80-100 degrees depending on disc-core combination in the nozzle. The nozzle should be angled 30-45 degrees from horizontal to obtain uniform distribution when used for broadcast application. This nozzle is generally used at 20-40 psi. These nozzles should also have 100% overlap and this boom height should be adjusted until this overlap is achieved.

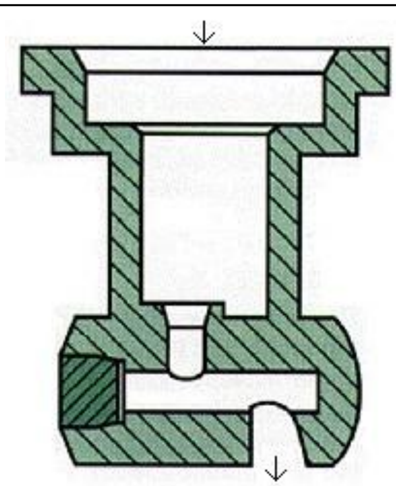

Figure 5. The Turbo Teejet® is an example of a nozzle with a turbulence chamber.

Turbulence Chamber Nozzle

The turbulence chamber nozzles have added a turbulence chamber to absorb energy within the nozzle and increase the size of the spray droplets. Examples of this design include the Turbo Teejet® and Turbo Floodjet® (Figure 5). While efficient for producing larger droplets than their traditional counterpart at low pressure, both also produce larger droplets at higher pressures, which is an advantage when spray controllers are able to vary the flow rate and pressure with equipment speed. Most are only available in smaller tip sizes.

Air Induction Nozzle

To increase droplet size and reduce drift, some nozzles (TurboDrop®, AI TeeJet®, Raindrop Ultra®) introduce air into the nozzle body by venturi action through an inlet port (Figure 6). The droplets containing air bubbles are generally larger than those produced by similar size nozzles with turbulence chambers. The air-filled droplets reportedly collapse when they hit the target to wet a greater leaf area. These nozzles work well with normal adjuvants and surfactants, but do not work as designed if drift control products are used. Compared to conventional nozzles, higher operating pressures, 40-60 psi, are suggested to maintain the desired pattern if pressure drops occur when using a spray controller. Most are only available in smaller tip sizes.

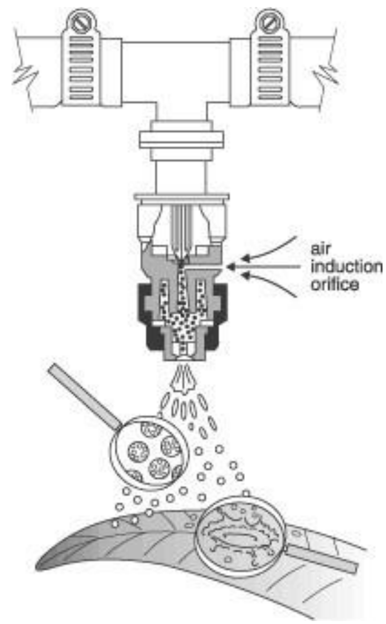

Figure 6. Air induction nozzles reduce drift at higher pressures when compared with traditional flat fan nozzles.

Boom with Special Accessories

CDA or Rotary-Cup Atomizer

The CDA (controlled droplet applicator) sprayer uses a grooved spinning cup that breaks the liquid into uniformly sized droplets by centrifugal force (Figures 7a and 7b). The spray solution flows into the bottom of a spinning cup under low

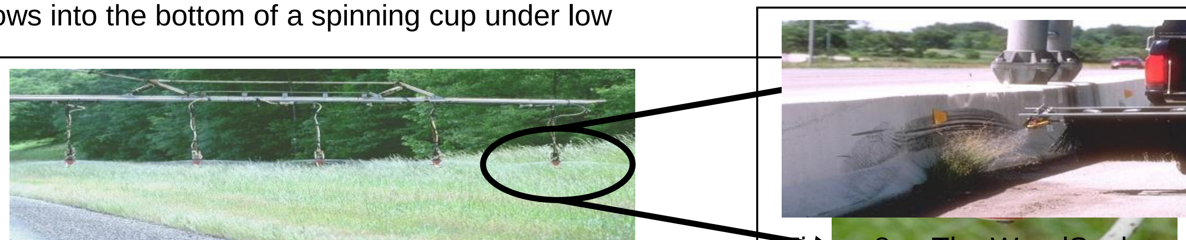

Figure 8a. The WeedSeeker

Figure 7a. A boom equipped with CDA unit

Figure 7b. A close-up view of a CDA

pressure and spreads evenly across the inner surface of the cup. Shallow channels or grooves on this surface deepen as they extend outward to the top. The spray solution moves up the grooves by centrifugal force and uniform droplets are released. The speed of the atomizer disc and the flow rate of the spray solution determine the droplet size. Power to spin the nozzles is provided by small electric motors. Sizes range from a small hand-held type to large truck-mounted units. Advantages of these sprayers include uniform droplet size and the use of low volumes of water per acre (less than 10 gallons). s disadvantages, they are relatively expensive, foliar penetration may be limited because there is no downward force on droplets, and they are not suitable for windy conditions.

Patchen WeedSeeker®

The WeedSeeker combines a sensor and a sprayer into a unit that uses variation in spectral reflectance to detect plants from other backgrounds and automatically treat them with herbicide (Figure 8a). Each WeedSeeker unit views an area 12 inches wide on the ground when mounted at the optimum height (Figure 8b). The WeedSeeker has an internal light source that emits a modulated light. This reduces variability due to clouds and shadows, and allows the WeedSeeker to operate at night. External solenoid spray valves can be activated with a valve driver cartridge installed in the WeedSeeker unit. This is recommended when using herbicide formulations other than soluble liquids. This will also allow the WeedSeeker to operate faster than 10 mph.

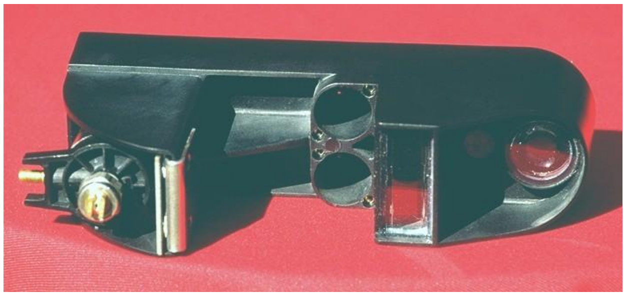

Figure 8b. A close-up view of the WeedSeeker.

Boomless Spraying

Boomless spraying enables the application equipment to stay on the tracks or roadside and spray areas off the side of the equipment. This results in a more uniform speed and rate of application as well as faster speed. Obstructions can interrupt the spray pattern but do not interfere with boomless spray application as much as with a boom application. Even though this equipment is usually mounted on the side of the application equipment, it can also be attached to the end of a boom to spray a wider swath or a greater distance from the equipment.

Off-Center Nozzle

Off-center (OC) nozzles tips are commonly used for railroad and roadside boomless spray applications. They

Figure 9. An OC nozzle (at the end of the boom) is often used to extend the swath width of a spray boom equipped with regular flat fan nozzles.

produce a flat fan spray pattern with the nozzle at the side rather than over the center of the pattern (Figure 9). OC nozzles are used either without a boom or at the end of booms to extend the effective swath width. The ability to treat a wide swath, the variety of sizes available to alter swath width and gallons applied per acre, the ease of mounting, and the low cost all contribute to the popularity of these nozzles. However, particle drift is a concern because of the wide range of droplet sizes produced by these nozzles. Spray droplets near the application equipment are small, while the droplets on the outer edge are large. Coverage can be variable because air turbulence distorts the spray pattern as it leaves the nozzles. They are usually permanently mounted to the application equipment at a height that gives a specific swath width. Because of the shape of the pattern, a slight change in height makes a substantial change in swath width and application rate. Drift control additives can be used with these nozzles.

Boom-Buster® Nozzle

The Boom-Buster nozzle is a straight stream diffuse nozzle. The spray solution is split by a plastic vane and forms a fan pattern very similar to the OC nozzle (Figure 10). The Boom-Buster nozzle produces larger droplets than a regular OC nozzle.

Figure 10. The Boom Buster® is often used in place of an OC nozzle.

Straight Stream Nozzle

Straight stream nozzles produce a solid stream pattern like water flowing from a pipe. These nozzles are used to spray a distant or specific target. For right-of-way application, they are most commonly used as a cluster of nozzles (Figure 11). Each part of the cluster is set to treat a defined section of the right-of-way. Some vibrating or oscillating action is usually added to aid in breaking the solid stream into smaller droplets. Swath width is

Figure 11. Straight stream nozzles are used to treat a wide swath to the side of the sprayer without using a spray boom. Vibrating the spray head breaks the streams into droplets.

adjusted by turning specific nozzles or sets of nozzles in the cluster off or on. They may also be attached to booms or in handguns to apply herbicides in a narrow band.

Radiarc®

The Radiarc is a group of straight stream tips aligned in a single plane like the fingers of a hand (Figure 12a and 12b). It uses an oscillating motion to mechanically break up the streams of spray solution. Swath width is adjusted by plugging selected tips. A Radiarc can be mounted to spray either a horizontal or vertical spray pattern. It can be adjusted to treat a swath from 4-25 feet wide. Uniform spray pattern is obtained by altering the sizes of the tips.

Figure 12a. The spray pattern of a Radiarc®.

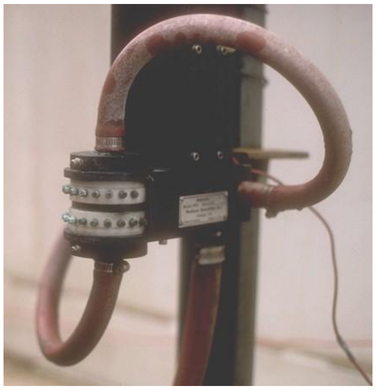

Figure 12b. A close-up view of the Radiarc®

Directa-Spra®

The Directa-Spra also uses straight stream nozzles. The units are fitted at the factory to spray an arc of 90, 180 or 360 degrees; 180 degrees is the most common. The nozzle clusters rotate around the center point (Figure 13). Swath widths from 10-25 feet and applications of 25-50 gallons per acre are obtainable.

Figure 13. The Directa-Spra® was created to control drift by using clusters of straight stream tips.

Injection Sprayers

Injection sprayers use an electronic controller to monitor the spraying operation and are most commonly used for roadside applications. The controller monitors equipment speed and swath width, and the operator adjusts the amount of chemical injected into the spray stream to maintain a constant herbicide rate of application. Equipment speed is measured with radar, or wheel or drive shaft rpm; swath width is previously defined for each set or cluster of nozzles. By knowing which nozzles are on, the controller determines how wide a swath is being treated. When the equipment speed is known, the area being treated per minute can be determined. Since the desired rate of chemical per acre has already been defined, the controller changes

Figure 14. Examples of spray controllers that maintain uniform application rates despite variation in sprayer speed.

the amount of chemical injected into the spray system whenever necessary to keep the amount of chemical applied per treated acre constant (Figure 14).

The chemicals are pumped directly from supply reservoirs so there is no tank mixing. The spray heads, clusters of straight stream nozzles, tilt and adapt to cut and fill slopes. The controller warns the operator if the desired application rates cannot be met by the system. Another advantage is that spray pressure remains constant so the spray pattern is uniform. Rates of chemical application can be changed at the operator’s discretion. The controller can separately control multiple boom sections.

When the herbicide injection is made at the suction side of the pump, there is a delay of several seconds before the injected chemical reaches the nozzle, or clears the hoses after injection has stopped. This time lag can represent a few hundred feet on the ground so the operator must be aware of right-of-way conditions well ahead of the equipment. Excess pump flow (bypass) must not be returned to the water tank since it contains the herbicide injected before the pump, and some will be returned to the tank. The nozzles in the spray head are set to spray particular sections of the roadside, and the controller is programmed to these widths. If the spray head is tilted up or down during application, these spray swaths change and misapplication can occur when the controller is unaware of the change.

Handgun applications are possible if the unit has been previously programmed. It will automatically adjust the amount of material injected into the spray stream to give a spray volume with the correct percent of herbicide. Some units can print an application record or incorporate a GPS receiver allowing some spraying functions to be done automatically.

Invert Emulsion Applicator

Emulsifiable concentrates (ECs) form an emulsion when added to water. This is seen as milky color because the oil droplets are surrounded by water. When water droplets are surrounded by oil, the mixture is termed an "invert emulsion" and has the texture of mayonnaise, which is a good example of an invert emulsion. This formulation was developed as a way of reducing drift because large droplets are formed when sprayed. The herbicide and the water are kept in separate tanks and are inverted at the pump. The invert emulsion is sprayed though a manifold generally mounted on the sprayer (Figure 15) and conventional application nozzles are not used. Because the spray droplet is surrounded by oil, the droplet does not dry as fast so plant absorption should be improved. The oil surface in contact with the leaf surface should also improve penetration. Both of these advantages could be particularly important in dry climates. Most liquid herbicide formulations can be applied with this equipment. If the amount of active ingredient in the mixture is too high, an invert emulsion cannot be formed.

Figure 15. An invert emulsion provides drift reduction and enhanced herbicide uptake.

Thinvert®

The Thinvert® application system consists of a patented series of spray nozzles and a patented thin invert emulsion spray fluid. The nozzles enable low volume applications in the range of 3-5 gallons per acre. The uniform droplets contribute to reduced spray drift. The thin invert emulsion is only slightly more viscous than typical oil carriers. However, the oil film on the outside of the drop greatly reduces droplet evaporation and enhances penetration through leaf cuticle and bark. Most herbicides can be applied through this system, even low-use-rate water dispersible granules. Optimum spraying pressure is about 60 psi. The system can be adapted for backpack sprayers, ATVs, tractors, trucks and other vehicles (Figure 16).

Figure 16. The Thinvert® has enhanced herbicide uptake and is applied at low gallons per acre.

DIRECTED LIQUID APPLICATION

Handgun

The handgun is a common and versatile type of spray equipment. It is used to treat accessible and inaccessible sites with spot and broadcast treatments. The handgun is attached to a hose that in turn is attached, through the pump, to any size tank holding the herbicide mixture. The handgun is usually adjustable to change the spray pattern from a solid stream to a wide cone pattern (Figure 17). Pump capacity (gallons/minute), hose diameter, and hose length limit the distance the applicator can move from the sprayer.

Figure 17. The handgun is a versatile piece of equipment.

Pump pressure in combination with the size of the orifice will determine the size of the droplet. The length and diameter of the hose used will determine the required pump pressure. The handgun is usually used for high-volume applications, generally more than 100 gallons of solution per acre, but any volume from 5–500 gallons per acre may be applied based on the target weeds and the need for uniformity of application. When equipped with off-center tips, it can be used as a boomless sprayer for low-volume application. All types of liquid formulations and drift control products can be applied.

The handgun can be equipped with a soil probe for injecting tree growth regulators into the soil around the base of a tree.

Backpack Sprayer

Figure 18. The backpack sprayer is quiet and very efficient when treating low numbers of stems per acre.

A backpack sprayer is a self-contained unit (tank and pump) and is carried on the back of the applicator (Figure18). The capacity of these sprayers is usually less than 5 gallons. A mechanical agitator plate may be attached to the pump plunger. The entire tank may be pressurized or only a small chamber that draws from the main tank. This equipment is useful for selective applications and spot treatments. Backpack sprayers are very adaptable to a wide range of nozzle configurations -- short booms, Boom Busters, or OC nozzles for broadcast treatments; adjustable cone nozzles, swivel tips, and rollover nozzles for treating individual stems as foliage or basal treatments.

Dual Spray Gunjet®

The dual spray Gunjet has been particularly useful for treating individual foliage with backpack sprayers but is adaptable to all types of sprayers. The traditional Gunjet is fitted with a unique roll-over valve that accommodates two spray tips with different volumes and different patterns (Figure 19). Only the front tip operates. A particular spray tip can be immediately switched to another by rotating the desired tip to the front position. Typically, one tip is a very narrow fan, about 15 degrees, and the other is a wider even fan tip, about 40 degrees.

Figure 19. The two different nozzles enable the applicator to treat trees close and at a distance by easily switching to a different nozzle.

Spaced Cuts and Cut Stump

Figure 20. Tree injection is an easy way to control trees too tall to treat the foliage.

Spaced cuts, also called “hack-n-squirt treatments”, are made around the tree, and small amounts of herbicide are added to the cuts. The cuts, approximately 1-2 inches wide, are spaced around the tree at about a one-inch interval, edge to edge (Figure 20). A small amount of herbicide, 1-2 milliliters, is added to each cut. This technique works best with water-soluble herbicides. Erratically spaced cuts result in incomplete control. Injection in the early spring during periods of rapid sap flow may cause reduced effectiveness of this technique.

Hardwood trees that are mechanically cut will generally resprout from the stump. Treating the cut surface of the stump with a herbicide immediately after cutting greatly reduces the incidence of sprouting. The herbicide should be applied to the cambial area of the stump (outer edge of the wood) where the bark and wood meet (Figure 21). It is not necessary to treat the entire stump. The herbicides effective in spaced cuts are also effective when applied to fresh cut stumps.

Figure 21. Only the outer edge of a fresh cut stump needs to be treated to reduce sprouting.

Wiping Applicators

Wiping applicators (also called rope wicks) rub the concentrated herbicide solution on the plant's leaf and stem surfaces (Figure 22). The rubbing surface can be a sponge, canvas, or a specially constructed rope that has an interior of parallel fibers for wicking and an outer sheath of nylon braid for durability. Hand-held wiping applicators usually are shaped like hockey sticks with the blade as the wiper and the shaft as the reservoir. Small units can be attached to backpack sprayers. Larger units typically have sections of exposed rope with the ends embedded in PVC pipe, which serves as the reservoir. They are relatively inexpensive and

Figure 22. Wiping applicators can be used to remove tall growing weeds from shorter desired plants.

easily built. Because only the weeds tall enough to contact the rubbing surface are affected, nonselective herbicides can be used selectively to release low-growing vegetation or vegetation below the treatment height. Drift does not occur with wiping applicators. They are difficult to use for broadcast applications on slopes or uneven surfaces.

Kline Injector

The Kline Injector is used to inject tree growth regulator into the ground (Figure 23). The injector allows applicators to place material into the soil by simply squeezing a handle. An electronic flow meter indicates exactly how much solution is injected. The injector automatically agitates the solution at pre-programmed intervals to ensure constant suspension. The basic unit of the Kline Injector easily adapts to a backpack, hand- or pull-cart or skid-mounted unit. The 12-volt battery powering the unit recharges when plugged into a charger supplied with the unit.

Figure 23. The Kline injector is used primarily to apply tree growth regulator around the base of the tree.

Mower Applicators

Brown Brush Monitor®

The Brush Monitor separates the operations of mowing and applying herbicides into two specialized chambers (Figure 24). The first chamber has cutting blades capable of

Figure 24. The Brown Brush Monitor sprays herbicide on the fresh cut stubble in the chamber behind the cutting blades.

handling 2-3 inch diameter stems. The cut debris is blown to the side of the mower. The remaining cut stubble is treated with herbicide in the second chamber. In the enclosed herbicide chamber, the stubble encounters two treatment phases. First, a row of nozzles sprays herbicides directly onto the stubble. Then, the system catches any unabsorbed herbicides in a series of scrapers, brushes and chains, which wipe product onto the stubble in the second application stage.

DRY APPLICATIONS

Pellets

Pelletized formulations vary in size with the product used. Smaller pellets can be applied with the same equipment used for applying granular formulations. The most common advantage of pellets is they can be spread by hand, with appropriate applicator protection. Backpack blowers have also been adapted to spread pelleted products. Pellets are a convenient method for treating inaccessible areas or small weed infestations. Several herbicide suppliers have developed hand applicators for use with their specific products.

Granules

Granular spreaders, which may be motorized or manually operated, are used to apply granular and pelletized formulations (Figure 25). They are of particular value in reaching areas not readily accessible to spray equipment. Granular applicators commonly used for rights-of-way sites distribute granular herbicides by spinning or whirling discs. The application is usually a broadcast treatment with even distribution over the entire area. Granular spreaders are typically inexpensive, simple in design, have minimal drift hazard, and afford less exposure hazard to the applicator. Granule formulations are typically more expensive per acre than liquid formulations and cannot be used for foliage applications because granules will not adhere to most foliage.

Figure 25. Granules and pellets can be applied with simple spreading devices.

Granule spreaders need to be calibrated for each product formulation, because formulations differ in particle size and bulk density, as well as for each operator. Some granular applicators are ground driven and it is important to maintain uniform speed so that application rates and swath width are not changed. Traveling too fast for ground conditions can cause bouncing of the equipment and uneven application. The spinning disc types may give poor lateral distribution, especially on side slopes. A granular applicator should be easy to clean and fill and have mechanical agitation over the outlet holes. This prevents clogging and helps keep the flow rate constant.

SUMMARY

There is an array of equipment available for applying herbicides. Each is designed for specific application situations. It is the responsibility of each applicator to use equipment correctly. The applicator controls the quality of the results.

Chapter 6 Example Test Questions

1. Spray nozzle performance depends on:
   A. All of the following
   B. Nozzle type
   C. Distance of nozzle from the target
   D. Operating pressure

2. Nozzle tips that are used evenly spaced on booms include:
   A. Regular flat fan
   B. Radiarc
   C. Whirl chamber
   D. Both A and C

3. Nozzles that produce a hollow cone spray pattern include:
   A. Off-center
   B. Raindrop
   C. Straight stream
   D. None of the above

4. Nozzles that should be angled 15-45o from horizontal include:
   A. Raindrop
   B. Straight stream
   C. Whirl chamber
   D. Both A and C

5. 11. An application device that rubs the herbicide on the leaf surface is:
   A. Trigger pump
   B. Spot gun
   C. Wiping applicator
   D. Hand gun

6. A commonly used nozzle for boomless spraying which produces a flat fan pattern is:
   A. Regular flat fan
   B. Off-center
   C. Straight stream
   D. None of the above

7. Mechanical spray devices for boomless spraying include:
   A. Radiarc
   B. Directa-Spra
   C. Vibrating clusters of straight stream tips
   D. All of the above

8. A boomless spray device that contains a group of straight stream tips, like the fingers on your hand, and that oscillates is the:
   A. Directa-Spra
   B. Radiarc
   C. Spot gun
   D. CDA

9. A spraying device that uses a grooved spinning cup to break the spray stream into uniform droplets and applies low gallons per acre is:
   A. Hand gun
   B. Boom-buster
   C. CDA
   D. Wiping applicator

10. Equipment typically used for spot treatment include:
    A. All of the following
    B. Backpack sprayer
    C. Trigger pump
    D. Spot gun

Answers:

1.	A	3.	B	5.	C	7.	D	9.	C
2.	D	4.	D	6.	B	8.	B	10.	A

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