Chapter 9

MIXING MATERIALS, CALIBRATING EQUIPMENT, AND CALCULATING AQUATIC HERBICIDE REQUIREMENTS

Section A—Mixing Materials

9-1. Determining Tank Capacity:

a. When the capacity of a spray tank is not known, or the tank is not marked to indicate the number of gallons it contains, set the sprayer or tank on a level place and gradually fill it with known quantities of water. Mark the water levels in gallons or fractions of a gallon on the side of the tank or on a calibration rod or stick held upright in the center of the tank. The marks can then be used to determine the quantity in the tank when it is partially filled.

b. To quickly approximate the capacity of a spray tank in gallons, use the following calculations. All tank measurements are in inches.

(1) For rectangular tanks:

$$\text{Capacity in gallons} = \frac{\text{length x width x depth}}{231}$$

Example:

If a tank is 60 inches long, 36 inches wide, and 30 inches deep, the capacity is about $\frac{60 \times 36 \times 30}{231} = 280$ gal

(2) For cylindrical tanks:

$$\text{Capacity in gallons} = \frac{\text{length x square of radius}}{73}$$

Example:

If a tank is 60 inches long and 30 inches in diameter, the capacity is about $\frac{60 \times 15^2}{73} = 197$ gal

(3) For tanks with an elliptical cross section:

$$\text{Capacity in gallons} = \frac{\text{length x (square of long diameter + square of short diameter)}}{462}$$

Example:

If a tank is 60 inches long, 36 inches wide, 24 inches deep, and elliptical in shape, the capacity is about

$$\frac{60 \times (36^2 + 24^2)}{462} = 243 \text{ gal}$$

9-2. Mixing Procedures:

a. Never pour a liquid concentrate or dry herbicide formulation into an empty tank. Either fill the tank with half of the water to be used, add the herbicide, agitate, and complete the filling, or add the herbicide gradually as the tank is filled. Agitate or stir until all solid material is dissolved or suspended.

b. If a water-soluble powder or crystalline form of herbicide is to be used with a liquid herbicide, dissolve the solid material in the water first, and then add and mix the liquid.

c. If oil is to be used in an oil-water or invert emulsion, premix the emulsifier and the oil-soluble herbicide with the oil in a separate container, and then add it slowly to a partly filled tank of water with constant stirring or agitation. Before using, circulate the mixture until it is uniformly white.

d. Agitate suspensions of water-dispersible powders and oil-water emulsions constantly or frequently during spraying to maintain a uniform spray mixture. Use the spray mixture within 1 or 2 days because some herbicides mixtures lose strength and deteriorate when standing.

e. Recommendations for herbicide application rates are based on the active ingredient or acid equivalent contained, not on the total weight of the product.

Section B—Calibrating Equipment

9-3. The Importance of Calibration:

a. The results of using herbicides depend greatly on how well, or poorly, the herbicides are applied. This, in turn, depends on the suitability of the equipment for the particular situation and the skill and care with which the operator uses the equipment. This is especially true of sprayers. Accurate application at the desired rate and uniform distribution of the material are essential for good results. A sprayer must uniformly distribute any quantity from 5 to 100 gallons or more per acre, because various weeds and situations may require a wide range of dilution for proper plant coverage.

b. Sprayer and spreader outputs should be calibrated for each particular treatment operation. A good procedure is to make initial adjustments to suit the machine and job requirements, and then to make a trial run to determine the machine's actual output. The herbicide mixture should then be prepared accordingly. The calibration should be repeated frequently to guard against nozzle orifice wear and other factors that affect performance. This is especially important when wettable powders and abrasive sprays are used.

c. There are many methods of calibrating a sprayer. A method is given here for each of the basic types of ground and aerial sprayers. Equivalent measures are shown in attachment 30.

9-4. Boom-Type Power Sprayers:

a. Determine that all nozzles are discharging uniformly by spraying water through them at a uniform pressure and catching the discharge from each nozzle in a separate container. If the amount of discharge varies widely, replace all nozzle tips that give a much larger or smaller discharge.

b. Place the sprayer on level ground, and fill the spray tank completely with water. Adjust the pressure of the sprayer to what it will be when used in the field.

c. Drive and spray exactly one-eighth of a mile (660 ft) in a field or along a road, ditchbank, or other typical spray area at the speed that will be used when spraying, usually 3 to 5 mi/h. Begin measuring the distance at the point where the spraying begins. Mark the throttle settings and the gear used, or make a note of the speed, and use this when spraying.

d. Shut off the spray, return the sprayer to its original position on level ground, and measure the water that is required to refill the tank (a quart jar is satisfactory).

e. Calculate the output per acre as follows:

$$\text{Gallons per acre} = \frac{\text{Number of quarts used x 16.5}}{\text{width of spray swath in feet}}$$

Example:

Water used = 7.5 qt
Spray swath width = 20 ft

$$\text{Output per acre} = \frac{7.5 \times 16.5}{20} = 6.2 \text{ gal}$$

f. To determine the amount of herbicide needed in each tankful, divide the number of gallons the tank holds by the number of gallons per acre that your sprayer applied. This is the number of acres each tankful will spray. Multiply this by the amount of herbicide recommended per acre.

Example:

Tank capacity = 55 gal
Output = 6.2 gal/a
Recommended rate per acre = 2 pt
Herbicide needed per tank = $\frac{55}{6.2} \times 2 =$ 17.7 pt, or 2.2 gal

g. In some row plantings, only narrow bands are sprayed, centered over each row, and the rate of treatment is in terms of the area actually treated and not acres of the crop. The rate of treatment is easily converted to a rate per acre of crop, however, if this is needed to calculate costs. With a 36-inch row spacing, if a 12-inch band is treated at a rate of 1.5 lb/a, the amount of chemical used per acre of cropland is $\frac{12}{36} \times 1.5 = 0.5$ lb.

9-5. Boom-Type Hand Sprayers:

a. Fill the sprayer to a marked point with water, maintain a constant tank pressure, and spray while walking steadily for 330 feet at the pace that will be used when spraying. Multiply 330 by the width of the spray swath in feet to obtain the area sprayed, and divide this by 43,560 (the number of square feet in an acre) to obtain the fraction of an acre sprayed.

b. Measure the amount of water required to refill the tank to the marked point. Convert pints or quarts to gallons by dividing by 8 or 4, respectively, and divide the gallons required by the fraction of an acre sprayed to find how many gallons were applied per acre.

Example:

Two nozzle boom, 20 inch spacing = swath width of 40 inches or 3.33 ft
Water required to refill = 5.5 pt, or 0.69 gal

$$\text{Area sprayed} = \frac{3.33 \times 330}{43{,}560} = 0.025 \text{ acre}$$

$$\text{Applied per acre} = \frac{0.69 \text{ gal}}{0.025} = 27.6 \text{ gal}$$

c. If too much spray is applied, walk faster or use smaller nozzle tips. Do the opposite to obtain more volume. For larger volumes, use nozzle tips that have larger orifices. Small changes in volume can be obtained with changes in pressure, but too low a pressure gives a poor spray pattern, and too high a pressure results in fine droplets prone to drift.

d. Determine the amount of herbicide required for each tankful by multiplying the area in acres that each tankful will spray by the recommended application rate per acre.

Example:

Tank capacity = 3 gal

Output = 27.6 gal

Area per tank = $\frac{3}{27.6}$ = 0.1 acre

Recommendedrate per acre = 2 pt

Herbicide needed per tank = 2 x 0.1 = 0.2 pt

9-6. Single-Nozzle Hand Sprayers. Fill the sprayer with water and apply it uniformly, in the same manner the herbicide will be applied, to a 1/100 acre area. An area measuring 43.6 feet by 10 feet is suitable. Determine the gallons applied per acre, and the amount of herbicide required per tankful, in the same manner as explained for boom-type hand sprayers.

9-7. Aerial Sprayers:

a. To determine the rate of flow per acre and per minute, put a known amount of spray or water in the tank or mark the level in the tank. Spray for a timed interval, for example 60 seconds (0.017 hours), while flying straight and level at the speed that will be used for spraying. Subtract the velocity of any headwind (or add any tailwind) from the airspeed to obtain the groundspeed. When the airplane lands, either measure the liquid remaining in the tank or measure the amount required to refill the tank to the same level. Compute the rate of spraying and the amount of herbicide needed as follows:

$$\text{Area sprayed} = \frac{\text{groundspeed (mi/h) x ft per mile x swath width x time in hours}}{43{,}560 \text{ ft}^2 \text{ per acre}}$$

$$\text{Applied per acre} = \frac{\text{gal used}}{\text{acres sprayed}}$$

$$\text{Herbicide needed per tank} = \frac{\text{tank capacity in gal}}{\text{gal spray per acre}} \times \text{application rate per acre}$$

Example:

Groundspeed = 75 mi/h

Width of effective swath = 40 ft

Time sprayed = 60 sec, or 1 min, or 0.017 hr

Gal used = 12.5

Tank capacity = 120 gal

Recommended rate per acre = 3 pt

Feet per mile = 5,280

Area sprayed = $\frac{75 \times 5{,}280 \times 40 \times 0.017}{43{,}560}$ = 6.18 acres

Applied per acre = $\frac{12.5}{6.18}$ = 2.0 gal

Herbicide needed per tank = $\frac{120}{2.0} \times 3$ = 180 pt, or 22.5 gal

b. Before spraying, equipment should be calibrated for swath width, volume and distribution of spray particles, and droplet size. Swath widths and droplet distribution patterns may be determined during calibration and at the application sites by using water-soluble marking dyes and rolls or sheets of white paper. The same drift-retardant additive should be used during the calibration as will be used during the actual application. A spray mixture of 8 ounces of nigrosine black per 50 gallons of water provides a distinctive pattern. With the boom and nozzle dispersing systems employed on mist aircraft, the effective swath width for uniform coverage is about the same as the wingspan, and should not exceed 1.5 wingspan width.

9-8. Dry Granule Spreaders. To obtain acceptable accuracy, mechanical broadcasters or spreaders for applying dry herbicide formulations must be calibrated with the actual material to be used and under the conditions that will be encountered in the field. Calibration is a simple procedure when calibration pans are available to catch the material for weighing during trial runs. A more complicated and wasteful procedure is required for spreaders that are not so equipped.

a. Mechanical Spreaders With Calibration Pans:

(1) Use a calibration pan, or, if one is not available, make one by cutting house gutter to the proper length, blocking the ends, and hanging it under the spreader with string or wire.

(2) Fill the spreader at least half full of the material to be applied. With the calibration pan in place, push or pull the spreader at the speed that will be used during application. Do this over terrain that is typical of that which will be treated, and go far enough to cover 1/100 acre, or 435.6 ft^2. For a spreader 3 feet wide, the distance should be 435.6 divided by 3, or 145.2 ft. For a spreader 8 feet wide, the distance would be 435.6 divided by 8, or 54.45 ft.

(3) Weigh the material in the calibration pan and multiply the weight by 100 to find the amount applied per acre.

(4) Adjust the feed mechanism as necessary and repeat the procedure until the desired rate is achieved.

b. Hand and Mechanical Spreaders Without Calibration Pans:

(1) Begin with a weighed amount of herbicide formulation. Apply the material to a measured area, preferably 435.6 ft^2 or 1/100 acre. Weigh the material remaining in the spreader, and subtract the weight from the initial weight to determine how much was applied. A shop vacuum-cleaner facilitates recovering the unused herbicide formulation. Make appropriate adjustments in the spreader, and repeat the procedure until the desired rate can be approximated in repeated trials.

(2) If the treatment period extends over several hours or days, occasionally check the rate being applied by weighing the amount to a measured area, and make any necessary adjustments.

Section C—Calculating Aquatic Herbicide Requirements

9-9. Applications Based on Water Surface Area. When the application rate is expressed in pounds or other units per surface acre, it is necessary to know the surface area of the body of water in acres. The amount of herbicide to be applied is determined by multiplying the application rate by the surface area.

a. The surface area of a rectangular body of water can be calculated by multiplying the length in feet by the width in feet and dividing the result by the number of square feet in an acre (43,560).

$$\text{Area in acres} = \frac{\text{length in ft x width in ft}}{43{,}560\ ft^2 \text{ per acre}}$$

b. The surface area of a circular body of water is calculated by multiplying the square of the radius in feet by 3.1416 and dividing the result by the number of square feet in an acre.

$$\text{Area in acres} = \frac{3.1416 \text{ x square of radius in ft}}{43{,}560\ ft^2 \text{ per acre}}$$

c. The radius is one-half the diameter. For bodies of water that are somewhat round, but not perfectly so, an approximate radius can be determined by measuring the perimeter in feet and dividing it by 6.28. The area in acres can then be determined from the formula above.

9-10. Applications Based on Water Volume. For herbicide treatments based on pounds of herbicide per acre-foot of water, it is necessary to know the surface area of the body of water in acres and the average depth of the water. The volume of water to be treated can then be determined in acre-feet. An acre-foot of water is the amount of water that can cover an acre to a depth of 1 foot. The amount of herbicide to be applied is determined by multiplying the application rate by the acre-feet of water to be treated.

Example:

Water surface area = 2.5 acres
Average water depth = 3 ft
Total volume of water = 2.5 x 3 = 7.5 acre-feet
Application rate = 4 lb per acre-foot
Herbicide required = 7.5 x 4 = 30 lb

9-11. Applications Based on Concentration. To determine the amount of herbicide required to treat a body of water when the application rate is expressed in parts per million (p/m) by weight, use the following calculations:

1 acre-foot of water weighs 2,722,500 lb
1 p/m by weight of an acre-foot of water = $\frac{2{,}722{,}500 \text{ lb}}{1{,}000{,}000} = 2.7$ lb

Herbicide required = acre-feet of water to be treated x p/m by weight desired x 2.7 lb

Example:

Water surface area = 5 acres
Average water depth = 4 ft
Water to be treated = 5 x 4 = 20 acre-feet
Application rate = 2 p/m by weight
Herbicide required = 20 x 2 x 2.7 = 108 lb

9-12. Applications in Flowing Water. The volume of waterflow must be accurately determined before treating flowing water to control aquatic weeds. Herbicide requirements are based on the volume of flow.

a. Weirs and other devices can provide accurate measurements of waterflow, or, in the absence of such devices, the approximate volume of flow can be obtained by determining the cross-sectional area of the channel in square feet (average water depth in feet x average width of the channel in feet) and the velocity of flow. A convenient and fairly accurate measurement of velocity of flow may be made by placing a dense floating object, such as a waterlogged stick, in the center of the channel and measuring the length of time in seconds that are required for

the object to travel a known number of feet. The velocity of the water in feet per second is found by dividing the distance traveled by the time required. This process should be repeated several times to obtain an average velocity in the section of channel where the width and depth measurements were made. The volume of flow can then be calculated as follows:

Water flow in ft^3/s = width in ft x depth in ft x velocity in ft/s x 0.9

b. When the application rate is expressed in terms of p/m by volume and minutes of treatment, then the amount of herbicide needed can be determined by the formula:

application rate in p/m by volume x water flow in ft^3/s x mins of treatment/2,220 = herbicide needed over a period of minutes.

Example:

$$\frac{\text{740 p/m by volume x 10 } ft^3/s \text{ x 30 minutes}}{\text{2,220}} =$$

100 gal of herbicide applied over a period of 30 minutes

c. When the application rate is expressed in terms of p/m by weight and minutes of treatment, then the following formula may be used:

Herbicide needed over a period of minutes = application rate in p/m by weight x water flow in ft^3/s x minutes of treatment/267

d. The amount of herbicide to be applied per minute during the treatment can be calculated as follows:

Volume (or weight) of herbicide to be applied per minute =

$$\frac{\text{total volume (or weight) of herbicide}}{\text{minutes of treatment}}$$

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SUMMARY OF CHANGES

This revision adds information on plant growth regulators and weed control in turf (chaps 5 & 6), horticultural plantings (chap 4, sec C), and aquatic sites (chap 7); and updates the text throughout.

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