3. Pesticide Application – Calibrating Chemical Application Equipment

Modified from the "Southeastern U.S. 2016 Vegetable Crop Handbook" by the Southeastern Vegetable Extension Workers (SEVEW) Group.

Calibrating Field or Backpack Sprayers

Preparing to Calibrate

For calibration to be successful, several items need to be taken care of before going to the field. Calibration will not be worthwhile if the equipment is not properly prepared. Calibration should be performed using water only. Follow the steps outlined below to prepare spraying equipment for calibration.

1. Inspect the sprayer. Be sure all components are in good working order and undamaged. On backpack sprayers, pay particular attention to the pump, control wand, strainers, and hoses. On boom sprayers, pay attention to the pump, control valves, strainers, and hoses. On air blast sprayers, be sure to inspect the fan and air tubes or deflectors as well. Be sure there are no obstructions or leaks in the sprayer. Be sure all components are in good working order and undamaged.

2. Check the label of the product or products to be applied and record the following:

- *Application Rate*. Gallons per Acre (GPA)
- *Nozzle Required*. Type, droplet size and shape of pattern
- *Nozzle Pressure*. Pounds per Square Inch (PSI)
- *Type of Application*. Broadcast, band, or directed.

3. Next, determine some information about the sprayer and how it is to be operated.

- *Type of Sprayer*: Backpack, boom, or air blast. The type of sprayer may suggest the type of calibration procedure to use.
- *Nozzle Spacing (Inches)*: For broadcast applications, nozzle spacing is the distance between nozzles.
- *Nozzle Spray Width (Inches)*: For broadcast applications, nozzle spray width is the same as nozzle spacing – the distance between nozzles. For band applications, use the width of the sprayed band if treated area is specified; use nozzle spacing if total area is specified. For directed spray applications, use the row spacing divided by the number of nozzles per row. Some directed spray applications use more than one type or size of nozzle per row. In this case, the nozzles on each row are added together and treated as one. Spray width would be the row spacing.

  In most cases, a backpack sprayer uses a single nozzle. Some sprayers use mini-booms or multiple nozzles. The spray width is the effective width of the area sprayed, being sure to account for overlap. If a sweeping motion from side to side is used, be sure to use the full width when walking forward. If spraying on foliage in a row, use the row spacing. Dyes are available to blend with the spray to show what has been covered.
- *Spray Swath (Feet)*: The width covered by all the nozzles on the boom of a sprayer. For air blast or other boomless sprayers it is the effective width covered in one pass through the field.
- *Ground Speed,* Miles per Hour (MPH). Careful and accurate control of ground speed is important for any type of sprayer application. Ground speed can be calculated using a test course and stop watch. For this procedure, measure a suitable test course in the field and record the time it takes to cover the course. Speed can be calculated with the following equation.

$$Ground\ Speed\ (MPH) = \frac{Distance\ x\ 60}{Seconds\ x\ 88}$$

  When using a backpack sprayer, you want to walk a comfortable pace that is easy to maintain. Choose a safe, comfortable speed that will enable you to finish the job in a timely manner. On tractor mounted sprayers, select a ground speed appropriate for the crop and type of sprayer used. Slow speeds will require more time to complete the task while high speeds may be difficult to control and unsafe. Choose a safe, controllable speed to finish the job in a timely manner.

4. The *discharge rate*, Gallons per Minute (GPM), required for the nozzles must be calculated in order to choose the right nozzle size. Discharge rate is dependent upon application rate; ground speed; and nozzle spacing, spray width, or spray swath.

   For applications using nozzle spacing or nozzle spray width (Inches):

$$\text{Discharge Rate} = \frac{\text{Application Rate x Ground Speed x Spray Width}}{5940}$$

   For applications using the spray swath (Feet):

$$\text{Discharge Rate} = \frac{\text{Application Rate x Ground Speed x Spray Swath}}{495}$$

5. Choose an appropriate nozzle or nozzles from the manufacturer's charts and install them on the sprayer. Check each nozzle to be sure it is clean and the proper strainer is installed with it.

6. Fill the tank half full of water and adjust the nozzle pressure to the recommended pressure. Measure the discharge rate for the nozzle. This can be done by using a flow meter or by using a collection cup and stopwatch. The flow meter should read in gallons per minute (GPM). If you are using the collection cup and stopwatch method, the following equation is helpful to convert ounces collected and collection time, in seconds, into gallons per minute.

$$\text{Discharge Rate} = \frac{\text{Ounces Collected x 60}}{\text{Collection Time x 128}}$$

7. On boom sprayers or sprayers with multiple nozzles, average the discharge rates of all the nozzles on the sprayer. Reject any nozzle that has a bad pattern or that has a discharge rate 10% more or less than the overall average. Install a new nozzle to replace the rejected one and measure its output. Calculate a new average and recheck the nozzles compared to the new average. Again, reject any nozzle that is 10% more or less than the average or has a bad pattern. When finished, select a nozzle that is closest to the average to use later as your "quick check" nozzle.

   On backpack sprayers or sprayers with a single nozzle, compare the discharge rate of the nozzle on the sprayer to the manufacturer's tables for that nozzle size and pressure. Reject any nozzle that has a bad pattern or that has a discharge rate 10% more or less than the advertised rate. Install a new nozzle to replace the rejected one and measure its output.

Once the sprayer has been properly prepared for calibration, the operator must select a calibration method. When calibrating a sprayer, changes are often necessary to achieve the application rates needed. The sprayer operator should understand what changes can be made to adjust rate and what the limits of each adjustment are. The adjustments and the recommended approach are:

Pressure: if the error in application rate is less than 10%, adjust the pressure.

Ground speed: if the error is greater than 10% but less than 25%, change the ground speed of the sprayer.

Nozzle Size: if the error is greater than 25%, change nozzle size.

The goal should be to have application rate errors less than 5%.

Calibration Methods

There are four methods commonly used to calibrate a sprayer:

- Basic
- Nozzle
- 128th acre and
- Area

The *basic*, *nozzle*, and *128th* acre methods are "time" based methods which will require using a stopwatch or watch with a second hand to insure accuracy. The *area* method is based on a test distance measured in the field. Each method offers certain advantages. Some are easier to use with certain types of sprayers. For example, the basic and area methods can be used with any type of sprayer. The 128th acre and nozzle methods work well for boom and backpack sprayers. Choose the most comfortable method and use it whenever calibration is needed.

Basic Method

1. Accurate ground speed is very important to good calibration with the basic method.

   For tractor mounted sprayers, set the tractor for the desired ground speed and run the course at least twice. For backpack sprayers, walk the course and measure the time required. Walk across the course at least twice. Average the times required for the course distance and determine ground speed from the equation below.

$$Ground\ Speed\ (MPH) = \frac{Distance \times 60}{Seconds \times 88}$$

   If the tractor or sprayer is equipped with a true ground speed indicator such as radar, ultrasonic, or GNSS, this speed can be used for calibration. Tractor tachometers and transmission speed charts are often not accurate enough for calibration purposes.

2. Calculate the application rate based on the average discharge rate measured for the nozzles, the ground speed over the test course, and the nozzle spacing, spray width, or spray swath on the sprayer.

   For nozzle spacing or nozzle spray width applications (measured in inches):

$$Application\ Rate = \frac{5940\ x\ Discharge\ Rate}{Ground\ Speed\ x\ Spray\ Width}$$

   For spray swath applications (measured in feet):

$$Application\ Rate = \frac{495\ x\ Discharge\ Rate}{Ground\ Speed\ x\ Spray\ Swath}$$

3. Compare the application rate calculated to the rate required. If the rates are not the same, choose the appropriate adjustment and reset the sprayer.

4. Recheck the system if necessary. Once you have acceptable accuracy, calibration is complete.

Nozzle Method

1. Accurate ground speed is very important to good calibration with the nozzle method.

   For tractor mounted sprayers, set the tractor for the desired ground speed and run the course at least twice. For backpack sprayers, walk the course and measure the time required. Walk across the course at least twice then average the times required for the course distance and determine ground speed from the equation below.

$$Ground\ Speed\ (MPH) = \frac{Distance \times 60}{Seconds \times 88}$$

   If the tractor or sprayer is equipped with a true ground speed indicator such as radar, ultrasonic, or GNSS, this speed can be used for calibration. Tractor tachometers and transmission speed charts are often not accurate enough for calibration purposes.

2. Calculate the nozzle discharge rate based on the application rate required, the ground speed over the test course, and the nozzle spacing, spray width, or spray swath of the sprayer.

$$Discharge\ Rate = \frac{Application\ Rate\ x\ Speed\ x\ Spray\ Width}{5940}$$

   For nozzle spacing or spray width applications (inches):

   For spray swath applications:

$$Discharge\ Rate = \frac{Application\ Rate\ x\ Speed\ x\ Spray\ Swath}{495}$$

3. Compare the rate calculated to the average rate from the nozzles. If the two don't match, choose the appropriate adjustment and reset the system.

4. Recheck the system if necessary. Once you have acceptable accuracy, calibration is complete.

128^{th} Acre Method

1. The distance for one nozzle to cover 128^{th} of an acre must be calculated. The nozzle spacing or spray width in inches is used to determine the spray distance. Spray distance is measured in feet. On backpack sprayers, be sure to measure the full width sprayed as you walk forward.

$$Spray\ Distance, Ft = \frac{4084}{Spray\ Width, In}$$

2. Measure the spray distance on a test course in the field. Check the ground speed as you travel across the course. Be sure to maintain an accurate and consistent speed. Travel the course at least twice and average the time to cover the course.

3. For backpack sprayers, collect the output from the nozzle for the time measured in step 2. For tractor mounted sprayers, park the sprayer, select the nozzle closest to the average, and collect the output for the time determined in step 2. Ounces collected will indicate application rate in GPA.

4. Compare the application rate determined in step 3 to the target rate required for the job. If the rates are not the same, choose the appropriate adjustment and reset the system.

5. Recheck the system if necessary. Once you have acceptable accuracy, calibration is complete.

Area Method

1. Determine the distance that can be sprayed by one tank using the full spray swath measured in feet.

$$Tank\ Spray\ Distance\ (FT) = \frac{Tank\ Volume\ (Gal) x\ 43{,}560}{Application\ Rate\ (GPA) x\ Swath\ (Ft)}$$

2. Lay out a test course that is at least 10% of the tank spray distance. Mark the level in the tank and travel the course. Be sure to maintain an accurate and consistent speed across the course. Carefully measure the volume required to refill the tank to the original mark.

3. Calculate application rate.

$$Application\ Rate\ (GPA) = \frac{Volume\ Sprayed\ (Gal) x\ 43{,}560}{Test\ Course\ Distance\ (Ft)\ x\ Swath\ (Ft)}$$

4. Compare the application rate measured to the rate required. If the rates are not the same, choose the appropriate adjustment method and reset the sprayer.

5. Recheck the system. Once you have acceptable accuracy, calibration is complete.

Calibrating Granular Application Equipment

Preparing to Calibrate

Granular application calibration is usually done with the chemical to be applied. It is difficult to find a blank material that matches the granular product. Extra care should be taken in handling this product. Worker exposure should be minimized and precautions taken against spills during calibration. Granular applicators are used to apply product to a crop row.

1. Before calibrating, equipment should be carefully inspected to ensure all components are in proper working order. Check the hopper, the metering rotor, the orifice, and the drop tubes. Be sure there are no leaks or obstructions.

2. Determine the type of application required for the product:

- Broadcast: treats the entire area.
- Band: treats only the area under the band.
- Row: treats along the length of the row.

3. Determine the application rate needed:
- Broadcast: Pounds per acre.
- Band: Pounds per acre of treated band width.
- Row: Pounds per 1000 feet of row length.

4. Determine the type of drive system the applicator uses:
- Independent: uses PTO, hydraulic, or electric motor drive.
- Ground Drive: use ground driven wheel.

5. Regardless of how the application rate is expressed or type of application, calibration is easier if the rate is expressed in terms of pounds per foot of row length. Use one of the following equations to determine the correct row rate in pounds per foot.

   For Broadcast Applications (Application Rate = Lb/Ac):

$$Row\ Rate\ \ \frac{Lb}{Ft}\ = \frac{Application\ Rate\ \ \frac{Lb}{Ac}\ \ x\ Row\ Width\ (Ft)}{43{,}560}$$

   For Banded Applications (Application Rate = Lb/Ac of Band Width)

$$Row\ Rate,\ \frac{Lb}{Ft}\ = \frac{Application\ Rate\ \ \frac{Lb}{Ac}\ \ x\ Band\ Width\ (Ft)}{43{,}560}$$

   For Directed (Row) Applications (Application Rate = Lb per 1000 Ft.)

$$Row\ Rate\ \ \frac{Lb}{Ft}\ = \frac{Application\ Rate\ (\frac{Lb}{1000Ft})}{1000}$$

6. Choose a calibration distance to work with and measure a test course of this distance in the field you will be working in. Choose an area that is representative of field conditions. The calibration distance should be at least 50 feet but not over 500 feet. Longer distances are generally more accurate.

7. Calculate the weight of material that should be collected for the calibration distance chosen.

$$Weight = Row\ Rate\ \ \frac{LB}{FT}\ \ x\ Calibration\ Distance\ (FT)$$

8. Select a ground speed appropriate for the crop and type of equipment used. Slow speeds take longer to finish the task while high speeds may be inefficient and unsafe. Consult your equipment manual for a recommended speed. Even ground driven application equipment can be sensitive to changes in speed. Maintaining an accurate and consistent speed is very important. Choose a safe, controllable speed that will enable you to complete the job in a timely and efficient manner.

9. Set the equipment according to recommendations from the equipment or chemical manufacturer. Most equipment manufacturers and chemical manufacturers provide rate charts to determine the correct orifice setting or rotor speed for each applicator. Fill the hopper at least half full to represent average capacity for calibration.

10. Attach collection container to each outlet on the applicator that collect all material discharged from the applicator. Locate a scale capable of weighing the collected samples. Some samples may be very small so a low capacity scale may be needed. Accuracy is very important when selecting a scale.

Calibration Methods

Two methods for calibrating granular applicators are commonly used. The first is the distance method. This method is preferred by many operators because it applies to any type of granular machine and is easy to perform. The second method is the time method. This method is similar to sprayer calibration and can be used for applicators driven by PTO, hydraulic, or electric motors.

Distance Method

1. On the test course selected in the field, collect the output from the applicator in a container as you travel the course and weigh the material collected. Record the time required to travel the course. Weigh the material collected. Run the course twice, once in each direction, and average the results for both weight and time.

2. Calculate ground speed to confirm you have the correct speed and can keep the speed constant.

$$Ground\ Speed\ (MPH) = \frac{Distance\ (ft)\ x\ 60}{Time\ (Sec) x\ 88}$$

   With a true ground speed indicator, such as radar or GNSS, use the speed indicated.

3. Determine the weight of the product that should be collected for the calibration distance.

$$Weight\ \ (Lb) = Row\ Rate\ \ \frac{Lb}{Ft}\ \ x\ Calibration\ Distance\ (Ft)$$

4. Compare the weight of the product actually collected (step 1) to the weight expected for the calibration distance (step 3). If the rates differ by more than 10%, adjust the orifice, rotor speed, or ground speed and repeat. Bear in mind, speed adjustments are not effective for ground driven equipment.

5. Repeat the procedure until the error is less than 10%.

Time Method

1. Accurate ground speed is very important to good calibration with the time method. On a test course, set the tractor for the desired ground speed and run the course twice. Average the times required for the course and determine ground speed in miles per hour from the equation below.

$$Ground\ Speed = \frac{Distance\ x\ 60}{Seconds\ x\ 88}$$

   If the tractor or sprayer is equipped with a true ground speed indicator such as radar, ultrasonic, or GNSS, this speed can be used for calibration. Tachometers and transmission speed charts are not accurate enough for calibration.

2. Set the orifice control as recommended and run the applicator for the time measured to travel the calibration distance.

   Determine the weight of the product that should be collected for the calibration distance.

$$Weight\ (Lb) = Row\ Rate\ \frac{Lb}{Ft}\ x\ Calibration\ Distance\ (Ft)$$

3. Compare the weight of the product actually collected for the time to cover the calibration distance to the weight expected for the calibration distance. If the rates differ by more than 10%, adjust the orifice, rotor speed, or ground speed and repeat. Bear in mind, speed adjustments are not effective for ground driven equipment.

4. Repeat the procedure until the error is less than 10%.

Calibrating a Broadcast Spreader

Preparing to Calibrate

Broadcast spreaders are machines designed to apply materials broadcast across the surface of the field. They include drop, spinner, and pendulum spreading devices. Calibration of a broadcast spreader is usually done using the product to be applied. Blank material is available and can be used, but may be hard to find. Use extra care and preparation when calibrating with the chemical.

To begin, follow these steps:

1. Carefully inspect all machine components. Repair or replace any elements that are not in good working order.

2. Determine the type of drive system is used: ground drive or independent PTO. This may help determine the method of calibration.

3. Determine the application rate and the bulk density of the product to be applied.

4. Determine the spreader pattern and swath of the spreader. The pattern should be checked to insure uniformity. To check the pattern, place collection pans across the path of the spreader. For drop spreaders, be sure to place a pan under each outlet. For spinner and pendulum spreaders, space the pans uniformly with one in the center and an equal number on each side. The pattern should be the same on each side of the center and should taper smoothly as you go to the outer edge. The swath would be set as the width from side to side where a pan holds 50% of the maximum amount collected in the center pan.

5. Fill the hopper half full to simulate average conditions.

6. Set the ground speed of the spreader. To determine accurate ground speed, use a true ground speed indicator such as radar, ultrasonic or GNSS or time the travel across a test course and calculate ground speed.

$$Application\ Rate, \frac{Lb}{Ac} = \frac{Weight\ Collected, Lb\ x\ 43{,}560}{Distance, Ft\ x\ Swath, Ft}$$

7. Set the spreader according to manufacturer recommendations and begin calibration.

Calibration Methods

There are two methods often used to calibrate broadcast spreaders. The first method is the discharge method. In this procedure, collect and measure the total discharge from the spreader as it runs across a test course. The second method, the pan method, is used on centrifugal and pendulum spreaders. The pattern test pans used to determine pattern shape and swath are used to determine application rate.

Discharge Method

1. Determine the test distance to use. Longer distances may give better accuracy but may be difficult to manage. A distance of 300 to 400 feet is usually adequate. Use shorter distances if necessary to avoid collecting more material than you can reasonably handle or weigh.
2. Set the ground speed. Be sure to maintain a constant ground speed at all times.
3. If using a ground drive spreader, attach a collection bin to the discharge chute or under the outlets and collect all the material discharged from the spreader as it runs across the test distance. If using an independent drive spreader, record the time required to run the test course. Park the spreader at a convenient location and measure the discharge from the spreader for the time measured on the test distance. The course should be run twice and the times averaged for better accuracy.
4. Calculate the application rate:

$$Application\ Rate, \frac{Lb}{Ac} = \frac{Weight\ Collected, Lb\ x\ 43{,}560}{Distance, Ft\ x\ Swath, Ft}$$

5. Compare the application rate measured to the rate required. Adjust and repeat as necessary.

Pan Method

1. Place pans in the field across the swath to be spread. Pans should be uniformly spaced to cover the full swath. One pan should be at the center of the swath with equal numbers of pans on each side. Use enough pans, eleven or more, to get a good measurement.
2. Make three passes with the spreader using the driving pattern to be used in the field. One pass should be directly over the center pan and the other passes at the recommended distance, or lane spacing, to the left and right of the center pass.
3. Combine the material collected in the pans and determine the weight or volume collected. Divide by the number of pans used to determine the average weight or volume per pan.
4. Calculate the application rate.

   If you are measuring the weight in the pans in pounds:

$$Application\ Rate, \frac{Lb}{Ac} = \frac{13{,}829\ x\ Weight, lbs}{Pan\ Area,\ \ Inches^2\ x\ Collector\ Efficiency}$$

   Collector efficiency is an estimate of how much product that lands in the pans will actually stay in the pan. If you do not know, assume 100%.

   If you are measuring the amount collected in the pans as a volume in cubic centimeters, use the following to calculate an estimate of weight in pounds for each pan.

$$Weight, LB = \left(\frac{Bulk\ Density, \frac{Lb}{Ft^3}\ x\ Volume, cm^3}{62.4} \right) x \frac{1\ Lb}{453.6\ Grams}$$

5. Compare the rate measured to the rate required. Adjust and repeat as necessary.

Using a Hand-Cranked, Hand-Held Spreader to Apply Herbicides in Container Nurseries

NC STATE EXTENSION

Weed management in nursery crops can be one of the most costly components of crop production. Producers of container nursery crops rely primarily on two methods of weed control—multiple applications of preemergence herbicides and hand-weeding. Regardless of which herbicide is applied, the product must be applied accurately and uniformly to achieve effective weed control and to avoid over-application, which may injure crops. Most preemergence herbicides used in container nurseries are formulated on granular carriers. The standard application method is with a hand-held, hand-cranked "belly-grinder" type of rotary spreader. Two of the more commonly used models are the Warren T7-II and the Solo 421S, but other models are available.

Photo 1. Example of variable granule distribution

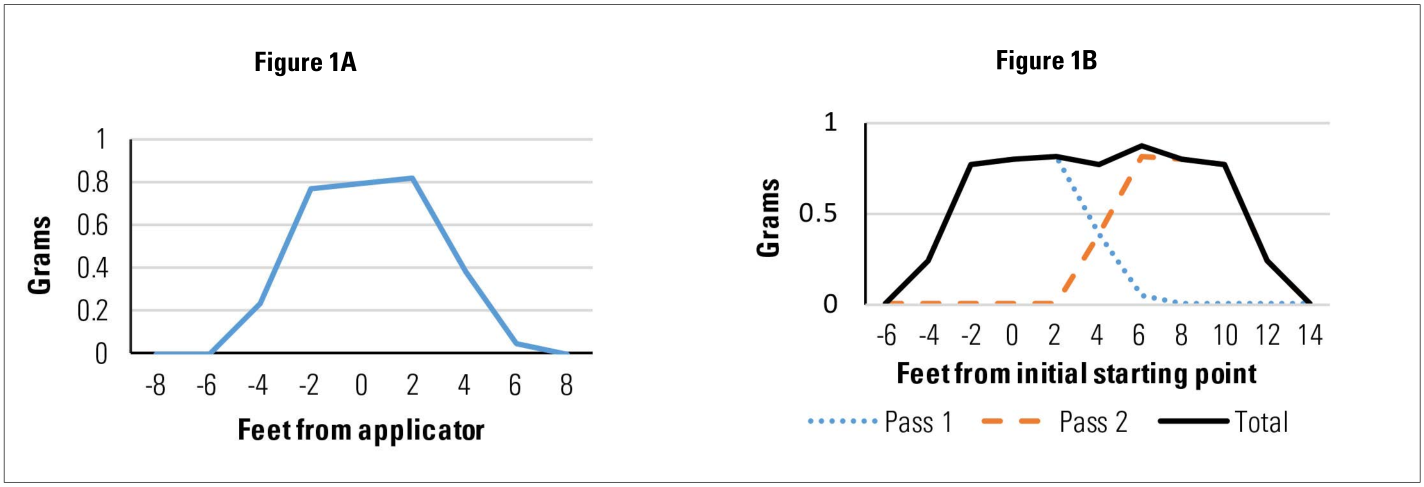
The uniformity of spread using these devices has been shown to be quite variable. We have measured granular herbicide applications at nurseries and found up to 250% variability from one pot to another within a container block. Increasing the uniformity of herbicide distribution will improve weed control and decrease the potential for crop damage. When using these granular spreaders, the most important factors affecting the distribution pattern and dose include: walking and cranking speed, swath width, rudder setting, amount of granule in the hopper, spreader output setting, wind speed, and walking patterns.

Granular Distribution Patterns

Granular spreaders typically have a distribution pattern in which the largest amount of granules is deposited directly in front of the applicator, with lesser amounts falling to the sides (Figure 1-A). To apply a uniform amount over an area, some overlap between passes is required.

Photo 2. Uniform herbicide distribution will result in better weed control.

Overlapping each side of the distribution pattern by 30 to 35% for a total of 60 to 70% overlap creates the most even application (Figure 1-B.) How close together the passes are, and as a result how much the passes overlap, is called the effective swath width.



Figures 1-A and 1-B. Figure 1-A is a typical pattern of granular distribution from a "belly-grinder" spreader. Overlapping passes by 30 to 35% will result in more uniform granular distribution, as shown in Figure 1-B.

Walking and Cranking Speed

The amount of granules applied to a given area is influenced by the applicator's walking speed. The faster you walk, the fewer the granules put out (Figure 2). A comfortable speed for most people is 3 mph, or 100 feet in 23 seconds. How fast you turn the spreader crank also influences the distribution of granules (Figure 3). When calibrating your spreader, make sure to use a speed that is comfortable. Then be consistent. You may use a metronome (Photo 3) to maintain constant walking and handle-cranking speeds. When using a metronome, try 99 to 103 beats for the walking speed and 60 for the handle-cranking speed.

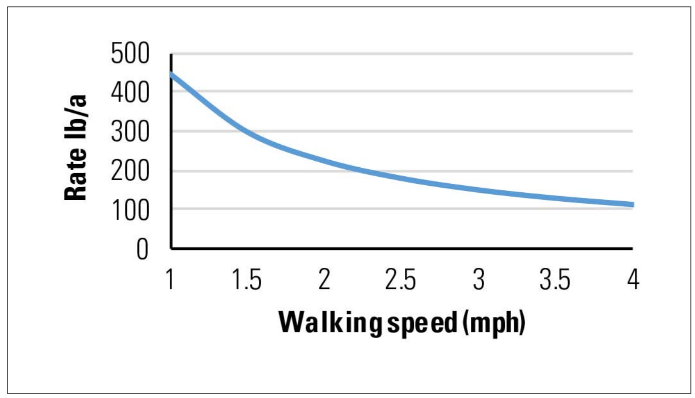


Figure 2. The faster you walk, the lower the application rate. Maintaining the speed you used while calibrating the spreader is important in maintaining a uniform application rate.

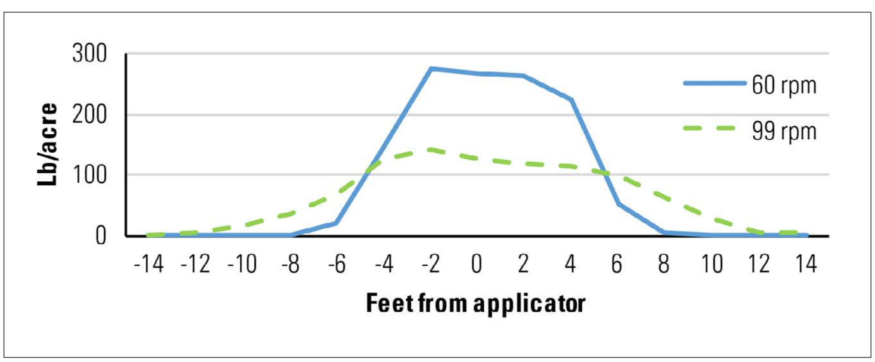


Figure 3. Comparison of two handle-cranking speeds. The faster speed resulted in a wider spread and lower rate than the slower cranking speed. Maintaining the handle-cranking speed used when calibrating the spreader helps keep the application rate and swath width consistent. Handle speeds are expressed as rotations per minute (rpm).

Photo 3. A portable metronome like this can help you maintain a consistent walking pace and cranking speed.

Swath Width

The distance between passes with a granular spreader (the swath width) has a large impact on application uniformity. For instance, with a 12-foot swath width, the average distribution pattern of FreeHand granules using a Warren T7-II spreader is very uneven (Figure 4). The gaps can be greatly reduced by using an 8-foot swath width instead (Figure 5). A swath width of about 8 to 10 feet works best for the average granule carrier.

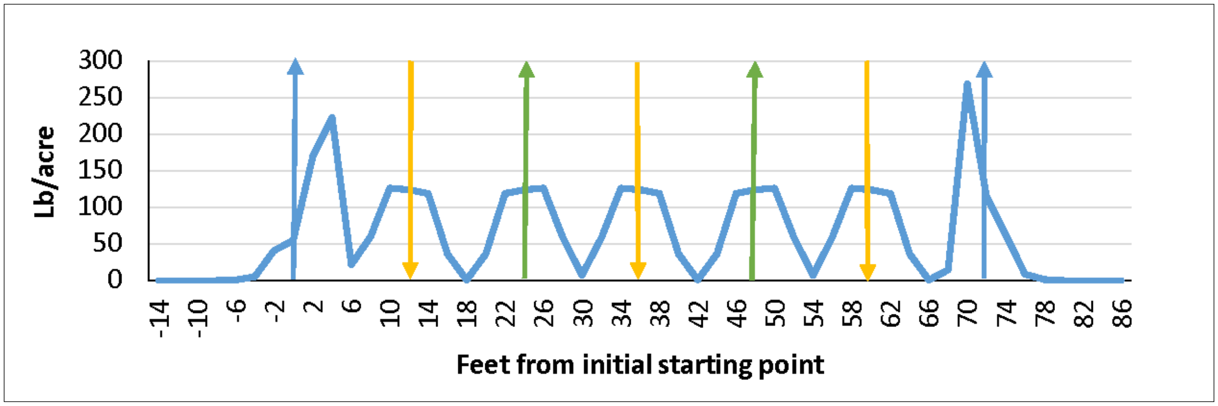


Figure 4. This spreader pattern reflects a 12-foot swath width; right, center, and left rudder positions; and the typical back and forth spreading pattern.

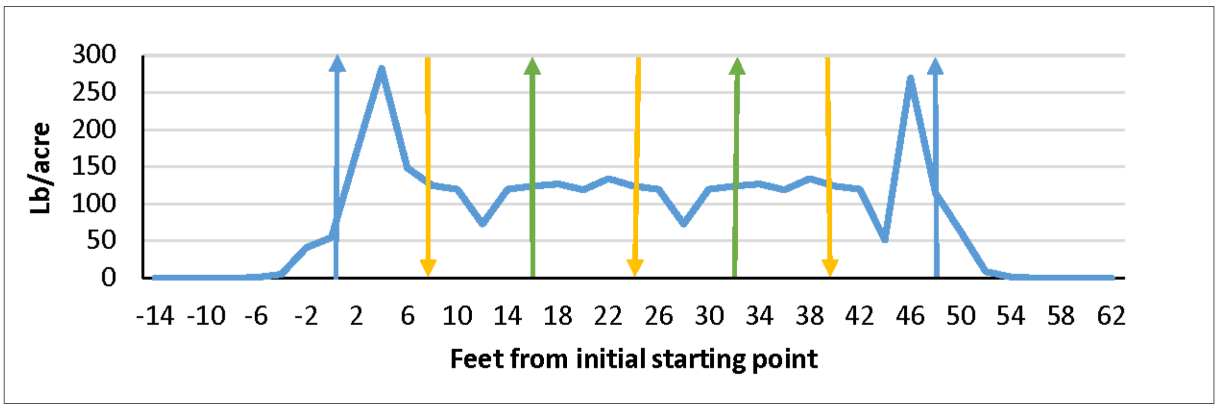


Figure 5. Having a narrower swath width improves application uniformity. This spreader pattern reflects an 8-foot swath width; right, center, and left rudder positions; and the typical back and forth spreading pattern.

Rudder Setting

Some spreaders can be adjusted to throw granules more to the right or the left, reducing the amount of product applied outside the container beds (Photo 4). However, using these rudder positions creates spikes in the amount of product applied to the outer edge of the application area (Figures 4, 5, and 6). This can be avoided by using only the center rudder position on spreaders with multiple rudder options (Figure 7). Holding the spreader at an angle while using the center rudder position also creates spikes in application and is not recommended.

Photo 4. Adjustable rudder positions on a Warren T-7 II spreader.

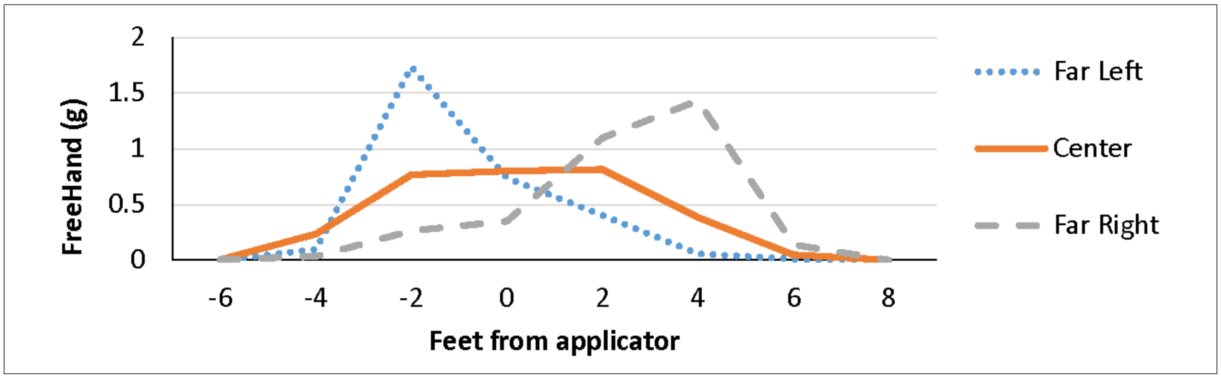


Figure 6. This typical granular distribution pattern was created from a Warren spreader by using the far left, center, and far right rudder positions. Using the left and right rudder positions created peaks in the amount of granules applied.

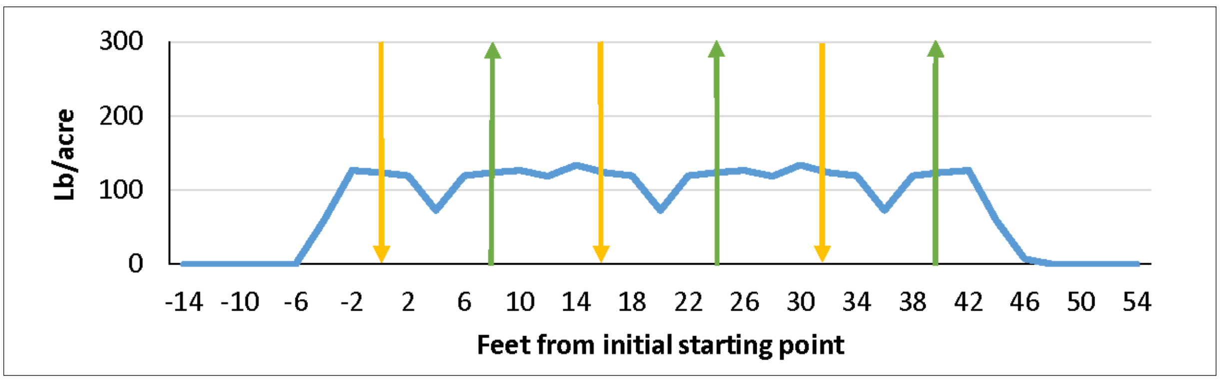


Figure 7. Using only the center rudder position improved spreader uniformity. This spreader pattern reflects an 8-foot swath width, center rudder position only, and the typical back and forth spreading pattern.

Amount of Granule in Hopper

Photo 5. Keep the spreader at least 25% full, as shown by the arrow.

The amount of product in the hopper at any given time affects the rate of application. Application rates can be as much as 45% lower when the hopper is only 10% full than when the hopper is completely full. Don't wait until the spreader is empty to refill. Add more granules when the level in the hopper drops to about 25% full (Photo 5).

Start Walking Before You Begin Spreading

Start walking and cranking the handle before opening the hopper. Otherwise, the spreader tends to drop a large amount of granules at the beginning (Photo 6). Waiting to open the hopper also helps prevent the spreader from jamming and dropping granules in one spot.

Photo 6. This pot received a HUGE dose of herbicide when the applicator opened the hopper before cranking the handle.

Wind Speed

If there are greater than 5 mph winds, do not use the granular spreader. Wind interferes with the uniformity of application. In Photo 7, notice how wind blew granules to the edge of the pot. This will inhibit root growth where the excessive herbicide is deposited and provide poor weed control where little or no herbicide is present.

Photo 7. Wind blew granules to pot edge.

Application Pattern (The Direction You Walk Can Make a Difference)

Applicators commonly walk a back-and-forth pattern (up one side and back the other) (Figure 8). This pattern provides an acceptable, balanced distribution only when the spreader is fully open (setting 6 on the Warren T7-II or Solo 421S spreaders), and only with a few herbicide granules (notably the clay granule used to make FreeHand G and Pendulum 2G). The fully opened setting may be appropriate for some herbicide applications, but lower settings are often required to achieve the desired application dose. When the lower settings are used, the distribution pattern is skewed more to the right (Figure 9-B). This will dramatically affect the uniformity of application (see Figure 10-A).

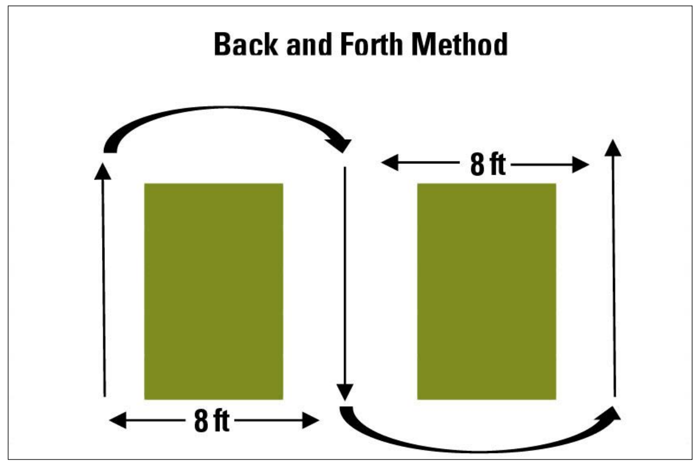
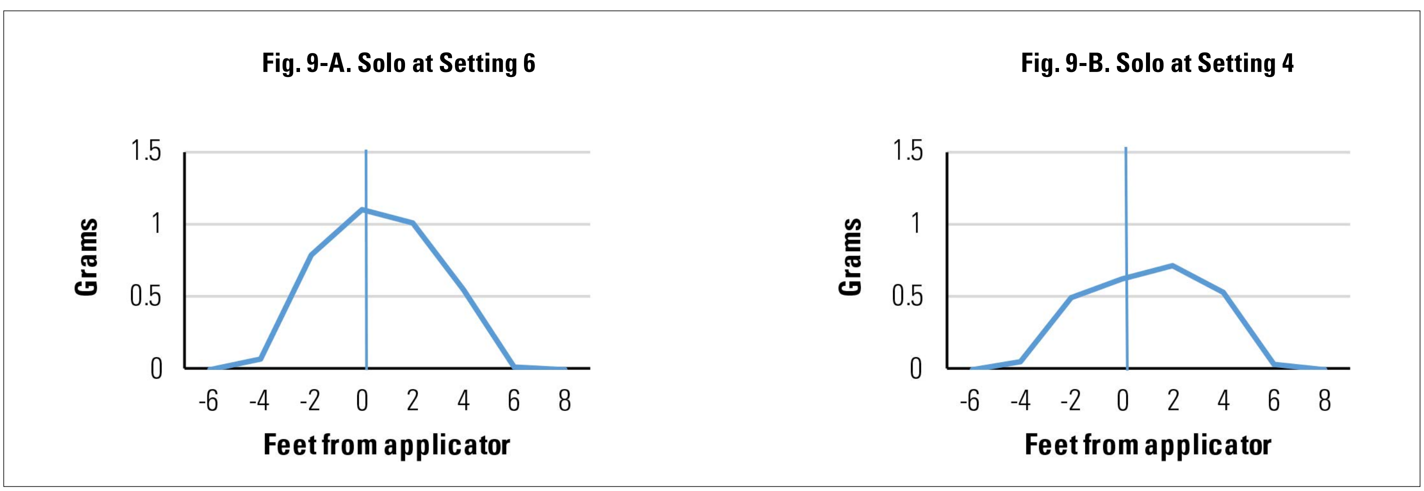
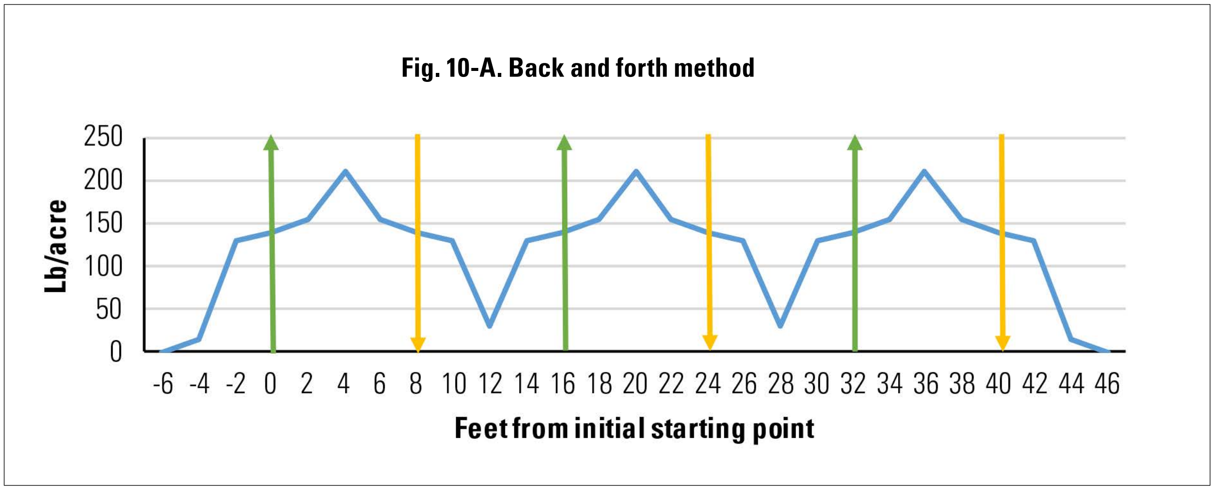


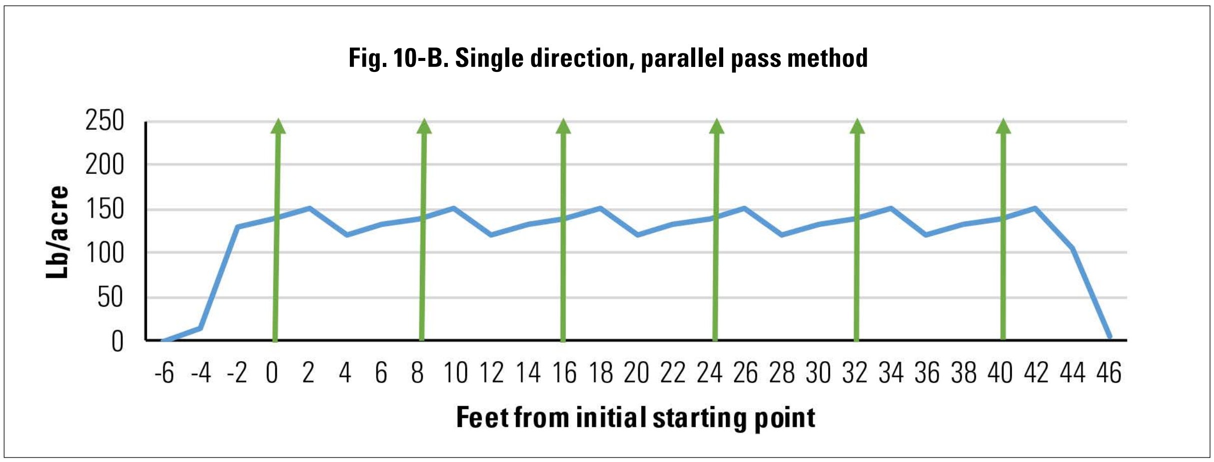
Figure 8. Typical back and forth application method.



Figures 9-A and 9-B. Sample granular distribution patterns at two spreader output settings. When the spreader is at the highest setting (Figure 9-A), the pattern is relatively uniform. But at lower settings, the spreader distribution is skewed to the right. Instead of being centered, the peak dose is 2 to 3 feet to the right of the applicator. The vertical lines mark the "center" position (where the applicator is walking).

There are two ways to compensate for this skewed pattern—change the direction of travel, making all applications while walking in the same direction (Figure 11-A), or make two passes over the same path in opposite directions (Figure 11-B). If you have calibrated your spreader to apply the full dose in one pass, then applicators must walk in the same direction (Figure 11-A). This might be most easily accomplished by having multiple applicators working together. Alternatively (and preferably), calibrate





Figures 10-A and 10-B. Sample granular distribution with a Solo spreader at Setting 4 with an 8-foot swath width, center rudder position, and a middle output setting. Figure 10-A illustrates the distribution pattern created when making parallel passes in two directions (back and forth). Figure 10-B illustrates the greater uniformity achieved when all passes are made in the same direction.

your spreader to apply half the target dose and walk the area twice in opposite directions (Figure 11-B). Remember—if you make two passes over the same path, you must calibrate your spreader to apply only half of the labeled dose each time.

Calibration

It is also important to know how much product your spreader is putting out. Great uniformity will still produce poor results if you're putting out too much or too little product. Test your application rate and adjust your walking speed and spreader setting as needed. More details on calibration can be found in Calibrating Hand-Held Granular Spreaders for Nursery Weed Control, https://content.ces.ncsu.edu/calibrating-hand-held-granular-spreaders-for-nursery-weed-control.

Tips for using Warren T-7 II and Solo 421S spreaders

- Maintain a consistent walking speed. Use a metronome.
- Maintain consistent cranking speeds. Use a metronome.
- The size of the beds matters! Keep nursery beds between 6 and 8 feet wide (for an 8- to 10-foot swath width).
- Only use the center rudder position. Do not hold the spreader at an angle.
- Refill the hopper when the level drops to about 25% full. Don't wait until it runs out.
- Start walking and cranking before opening the hopper.
- If the wind is 5 mph or more, don't make the application. Wait for a calmer day.
- When using lower spreader settings, spread granules using the single direction, parallel pass method.
- Calibrate your spreader!

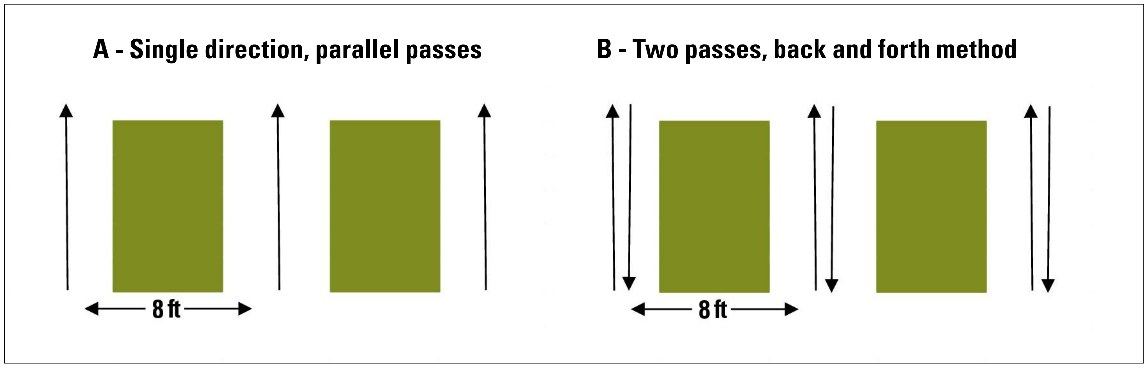


Figure 11. The single direction, parallel pass method involves walking up and down between each bed, but only spreading in one direction. The, arrows represent walking while spreading granules. The other option is to make two passes by walking up and down between each bed, spreading in both directions at half the labeled rate.

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https://content.ces.ncsu.edu/using-a-hand-cranked-hand-held-spreader-to-apply-herbicides-in-container-nurseries

Calibrating Hand-Held Granular Spreaders for Nursery Weed Control

NC STATE EXTENSION

Even the best herbicides will not provide effective weed control if they are not applied accurately and uniformly. Too little product results in poor weed control and higher hand-weeding costs. Too much can injure crops, reducing the number available for sale. Most granular herbicide labels contain some recommended settings for common application equipment. However, these recommendations **are just starting points**. To obtain the correct dose, you need to calibrate the spreader. Spreader calibration is essentially a very simple process:

1. measure the width of spread;
2. apply the granules to a small area;
3. measure the amount applied to this area;
4. compare this amount to the desired dose and adjust the spreader settings until the desired output is obtained.

Simple, right? However, in practice, this is easier said than done. In this fact sheet we cover the steps required to determine the effective swath width and application rate.

THE IMPORTANCE OF MAINTAINING A CONSISTENT SPEED

Both your walking speed and the speed at which you turn the spreader handle will influence the rate at which the product is applied. A consistent speed will help maintain a uniform application rate and distribution. See the fact sheet AG-826, Using a Hand-Cranked, Hand-Held Spreader to Apply Herbicides in Container Nurseries for more information on how walking speed affects spreader output.

Figure 1. A portable metronome like this can help you maintain a consistent walking pace and cranking speed.

Walking Speed

- Measure a distance of 100 feet in an area that is similar to the location where you will be applying the granules.
- Using a stopwatch, determine how long it takes to walk 100 feet. Most spreader manufacturers recommend walking about 2 to 3 mph. At 3 mph it takes about 23 seconds to walk 100 feet. A 2 mph pace requires about 34 seconds per 100 feet.
- You may use a metronome to help keep a consistent walking speed (Figure 1). Experiment with a few different settings until you find one that allows you to walk at the desired pace. To achieve a 3 mph pace, a good starting point is between 99 and 103 beats per minute. But this number will be different for different applicators. A mobile phone application metronome also works.
- The metronome can be clipped to the spreader while applying the granules.

Handle Cranking Speed

- Turn the spreader crank at a consistent speed that is easy to maintain — generally one rotation per second.
- You can practice with the metronome set to 60 beats per minute until you can walk with a consistent pace.

SPREADER CALIBRATION STEP 1: DETERMINING THE EFFECTIVE SWATH WIDTH AND DISTRIBUTION PATTERN

Granular spreaders do not distribute the same amount of material across the width of the treated area. More granules are deposited directly in front of the applicator than at the edges. Consequently, the applicator will have to overlap each pass when applying herbicides. For this reason, you need to determine the *effective swath width.* The effective swath width will be narrower than the entire width of spreader throw. Here are the supplies you will need:

- Granular spreader
- Herbicide of choice
- 7 to 9 containers such as catch bins, trays, or 1 gallon (3 or 4L) nursery pots lined with plastic bags
- Measuring tape
- A small scale (able to measure 1 gram)
- Metronome (battery operated, clip on)
- Stop watch
- Numbered bags/jars to hold herbicide granules
- Personal protective equipment

Steps

1. Set out the catch pans or bins 2 feet apart on center, perpendicular to the direction you will be walking (Figure 2 and Figure 3). Place the pans on a flat, dry, and empty nursery bed covered with landscaping fabric or plastic.

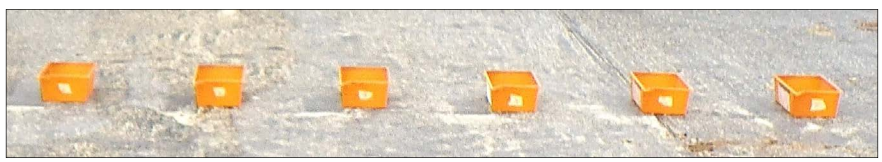

Figure 2. Layout of catch bins, two feet apart, on center.

2. Mark a starting point about 20 feet in front of the center box. Mark a point along your walking path to open the hopper (at least 12 feet in front of the center box).
3. Practice walking toward the boxes at a consistent pace, using a steady handle cranking speed and stepping over the center box (use the metronome).

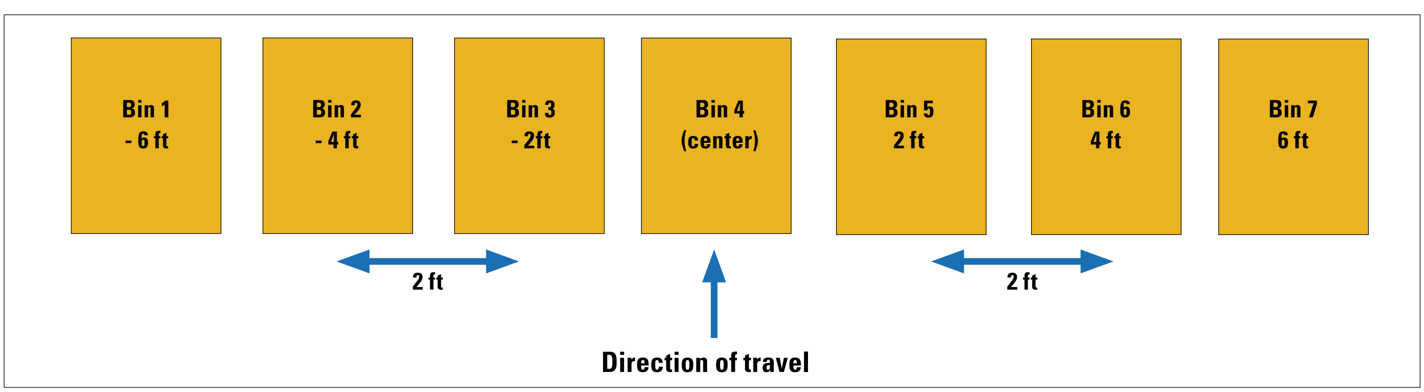

Figure 3. Calibration catch pan/tray setup. Set collection trays or bins 2 feet apart, on center. Walk down the center (carefully stepping over the center collection tray). Repeat at least three times.

4. Fill the spreader at least ½ full.
5. Use the center rudder position (or just right of center) as shown in Figure 4.
6. Adjust the spreader to the herbicide manufacturer's recommended output setting and spread granules while walking toward and over the boxes. Open the hopper at least 12 feet in front of the center bin and always walk toward the bins from the same direction. Keep the hopper open until just past the catch bins. Repeat the process at least two more times. *NOTE: When spreading, start turning the handle before you open the spreader hopper and continue turning the handle after closing the hopper until no more granules spread out. This helps reduce spreader jamming.*
7. Weigh the granules collected in each bin.
8. Measure the weight of granules collected in the center bin. Divide this number by two and find the collection bins on either side of center that have about half as much product as the center bin. The distance between the two bins is the effective swath width (Example A).
9. To determine the distribution pattern (Example B), use a piece of graph paper to chart the amount of granules in each bin and draw a line through the center (Figure 5). If the pattern is lopsided, plan to spread granules in one direction or make two passes in opposite directions over the same path.
10. If the test site was dry, you can sweep up the granules and reuse them.

Figure 4. Use only the center rudder position (or just right of center) to achieve the most uniform pattern.

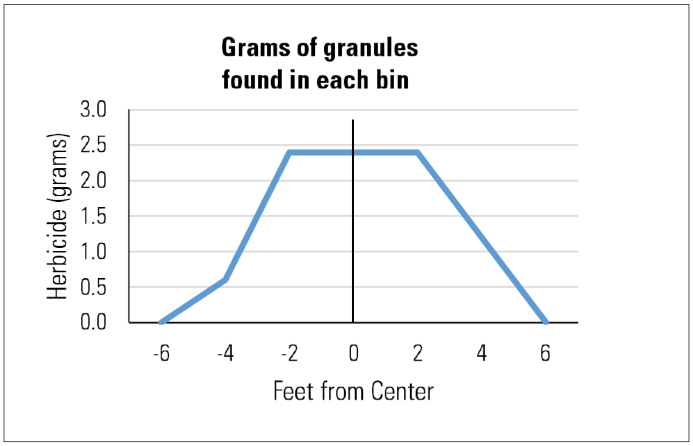

Figure 5. Distribution pattern created by graphing the amount of herbicide in each bin.

Example A: Determining the Effective Swath Width

In this example, the weight of the herbicide collected in each bin is recorded in the chart below.

	Collection tray or bin (by distance from center)						
	- 6 ft	- 4 ft	- 2 ft	**0**	2 ft	4 ft	6 ft
	(left of center)			**(center)**	(right of center)		
Grams collected	0.0	0.6	2.4	**2.4**	2.4	1.2	0.0

- 2.4 grams were collected in the center bin. Half that amount would be 1.2 grams.
- The bin 4 feet to the right of center contained this amount.
- On the left side, the area to receive 1.2 grams of material would be about halfway between the bins 2 and 4 feet left of center.

Thus, we would conclude that the effective swath width would be from about 3 feet left of center to 4 feet right of center, or 7 feet wide. This is the width used in Spreader Calibration Step 2: Determining the Application Rate.

Alternative Swath Width Method

If you don't have a scale, you can use a technique developed by Dr. Wayne Buhler, NC State University Pesticide Education Specialist. This approach uses a clear seven-day pill organizer to visually estimate swath width (Figure 6). *Caution: clearly label the box as having been used with pesticides and keep the box in the pesticide storage facility.*

- Label each compartment with the number of feet from the center. Keep left and right of center orientation clearly marked.
- After collecting granules as described in steps 1 through 6, use a funnel to put the contents of each collection bin into the corresponding sections of the pill box.
- Locate the compartments with about ½ as much product in them as the center compartment. This allows you to find your swath width and basic distribution pattern.

Figure 6. A clear pill box can be used to determine the swath pattern. The numbers correspond to the distance from center (in feet) as in Example A.

Figure 7. A milk scale, or a similar scale, can be used to weigh the spreader.

Example B: Determining Distribution Pattern

Graph the amount of granules in each bin (Figure 5). This particular distribution pattern is balanced with similar amounts spread to the left and right. However, depending upon the granule, the spreader, and the dose applied, the amount spread to the right may be greater than the amount applied to the left.

SPREADER CALIBRATION STEP 2: DETERMINING THE APPLICATION RATE

Bins, trays, and pots are useful for collecting granules when determining swath width. However, our research indicates that they are not a reliable tool for calculating the application rate. Instead, it is better to weigh the amount of herbicide applied to a known area, and then adjust the spreader settings to obtain the desired dose.

1. Fill the hopper on the spreader at least ¾ full of product.
2. Weigh the filled spreader and record the weight (Figure 7).
3. Operate the spreader over a known distance (at least 25 feet).
4. Reweigh the spreader and subtract the current weight from the original weight to determine how much product was used.
5. Calculate the area covered (distance the granules were spread multiplied by the swath width of the spreader).
6. Calculate the dose (weight of granules used divided by the square feet of area covered).

7. Adjust the spreader output setting or your walking speed until your application dose is within 10% of the labeled (or target) dose.

For more information on determining application rates using granular spreaders, see North Carolina State University publication AG-628, The Calibration of Turfgrass Boom Sprayers and Spreaders.

Example C: Determining the Dose

- Assumptions:
  - Labeled (target) herbicide dose: 150 lb/A
  - Effective swath width: 7 ft
  - Length of walking area: 30 ft
  - Area = 210 sq ft (swath width x length of area treated)
- Beginning weight of spreader with herbicide granules: 195 oz
- Ending weight of spreader with herbicide granules: 186 oz
  - Difference: 9 oz applied
- Convert ounces to pounds: 9 oz ÷ 16 oz per lb = 0.56 lb applied
- Calculate the dose:
  - Divide the amount applied by the area to obtain the amount per sq ft:
    0.56 lb ÷ 210 sq ft = 0.0027 lb/sq ft
  - Multiply by 43,560 (number of sq ft per acre) to obtain the dose in lb/A.
    0.0027 lb/sq ft x 43,560 sq ft/ acre = 118 lb/A
- This dose is more than 10% below the target dose of 150 lb/A. Adjust the spreader settings (or walking speed) to allow slightly more output and repeat the process until the rate falls within the acceptable range (135 to 165 lb/A).

You will need to follow this calibration procedure for each herbicide.

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