



TECHNICAL NOTE 23.

CALIBRATING LARGE CENTRIFUGAL SPREADERS FOR GRANULAR FERTILIZER

23.0 BACKGROUND

Centrifugal fertilizer spreaders are different from drop spreaders in that the metering device consists of a spinning impeller that throws the fertilizer granules 360 degrees away from its center point. Fertilizer is directed to the impeller from an inverted cone shaped hopper via gravity flow (**Figure 1**). Large capacity bed-type spreaders may have a chain drive belt mechanism that conveys the fertilizer to the orifice. The rate of delivery is controlled by one or more sliding gates that vary the opening of an orifice in the hopper (**Figure 2**). On tractor mounted spreaders, the speed of the impeller is controlled by the tractor's power take-off (PTO). Increasing the tractor's PTO speed increases the throw distance.

Usually it is not practical to collect the output for weighing nor is it practical to empty the spreader hopper to determine the amount of fertilizer that has been discharged. Furthermore, the distance that fertilizer granules are thrown varies with PTO speed, particle size and density. In general, large, dense particles are thrown further away than small, light particles. Particle size is more important than density because the mass of a particle varies as the cube of the radius, i.e. doubling the diameter of a particle will increase the mass 8-fold, whereas the densities of particles seldom vary by a factor greater than 3-fold from the lightest particles.



Figure 1.



Figure 2.

This technical note explains how to calibrate a tractor mounted centrifugal spreader. In addition, we briefly discuss the factors affecting fertilizer distribution and application uniformity.

23.1 CALIBRATION PROCEDURE

Calibration of centrifugal spreaders is a two-step process: (1) determine the **effective swath width** of the spreader, and (2) adjust the **application rate**. The two involve entirely different processes and are calculated independently.

The **working swath width** is the distance that fertilizer granules are thrown from the center point of the **rotary impeller**, measured in meters (SI) or feet (English). Since the tractor intercepts the granules for $\frac{1}{2}$ of a 360 degree circle, the **distribution pattern** appears as shown in **Figure 3**. Swath width is measured as the distance between the furthest granules on either side of the center line of the impeller. It's a fact that distribution of fertilizer granules is not uniform across the swath width. Reasons for non-uniformity include:

- o Differences in particle size and density
- o Physical properties of the granules, i.e. **coefficient of friction** and surface roughness
- o Wind
- o Humidity
- o Change in manufacturing process
- o Impeller spout angle and surface roughness
- o PTO speed

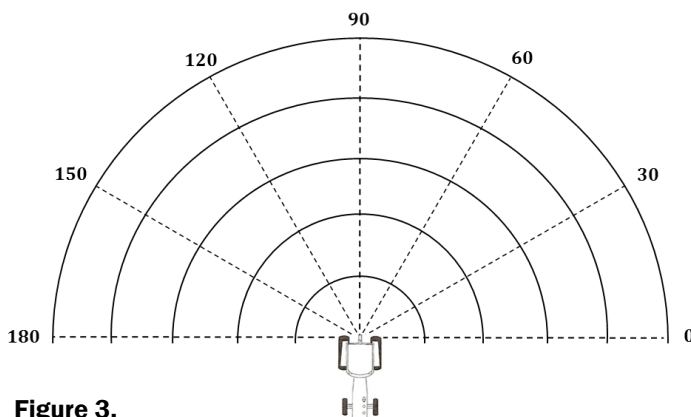


Figure 3.

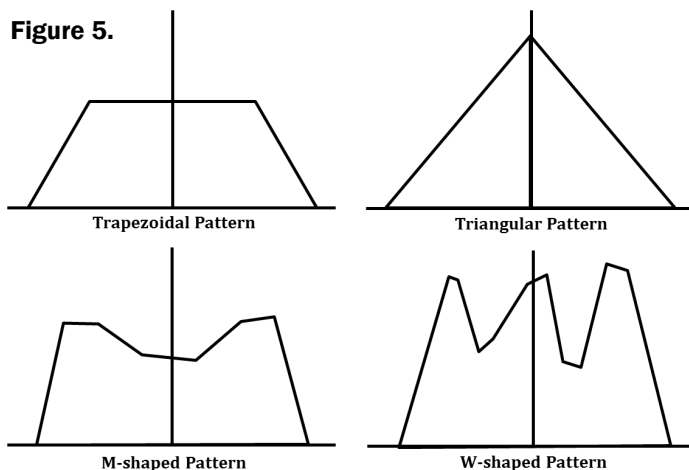
Applicators have control over PTO speed, spreader height and level but seldom have control over the other factors. Thus it is necessary to determine an effective swath width for each fertilizer material to ensure a reasonable degree of application uniformity.

The general procedure for testing the distribution pattern for centrifugal spreaders is the collection pan method (**Figure 4**). Here, a series of collection pans are placed at even intervals on the ground in a straight line perpendicular to the direction of spreader travel. Space between collection pans is adjusted to allow for the operation of the tractor and spreader over the collection pans. Material collected in pans is then weighed and the resulting data is used to compute the distribution pattern. Distribution patterns can take many shapes, as shown in **Figure 5**. The trapezoidal pattern is where application uniformity is high for a distance on both sides of the center line, gradually dropping off at the ends. The triangular pattern has a distribution that drops off gradually on both sides of the center line. Trapezoidal and triangular patterns are most effective because their feathering ends provides for a uniform application rate when properly overlapped. M- or W-shaped patterns are less effective and can create problems with uneven overlapping. **Figure 6** shows how the pattern of granular application decreases with increasing distance from the center point. Note that the distribution pattern roughly coincides with a triangle rounded at its apex.

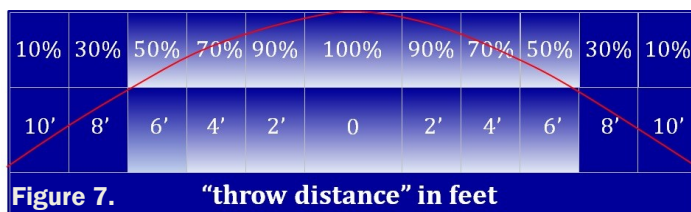
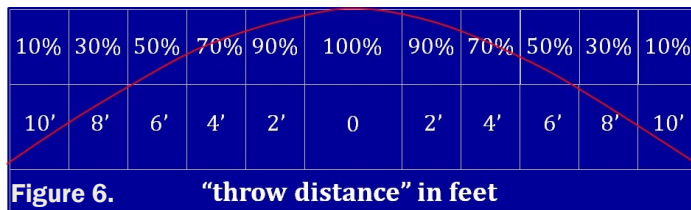
Figure 4.



Figure 5.



The collection pan method provides the most accurate information about pattern distribution for centrifugal spreaders. Often, in the field, we are faced with computing the effective swath width without knowledge of the distribution pattern for a spreader or for a particular granular fertilizer. The collection pan method may be impractical under these circumstances but we still need to calculate the effective swath width and overlap to calibrate. A general rule of thumb is that an effective swath width is where the application rate is not less than 50% of the amount at the center point. In **Figure 7** this is 6 feet left and 6 feet right of the center line, or approximately 60% of the working swath width. The effective swath width is 12 feet.



Following is a simple visual method for determining effective swath width in the field.

1. Stake off a swath of 30 feet. The exact width at this point is arbitrary but information printed on the spreader usually includes working swath widths for several different granular materials at PTO rated speed, so providing a starting point for the measurement.
2. Place a marker at the center point of the swath.
3. Align the center point of the spreader and tractor over the marker.
4. Adjust the tractor's lift and top links so that the spreader is level with the ground side-to-side and fore and aft. Adjust stabilizers so that the spreader is centered with respect to the tractor.
5. Position two people behind the spreader, each person aligned with the left and right side stakes.
6. Start the tractor and adjust the tractor's engine rpm to match the design PTO speed (usually 540 rpm for standard 6-spline PTO shafts).
7. Raise the lift links to the field operating height (about 1.5-2 feet over the canopy is most effective).
8. With the tractor operating in a stationary position, engage the PTO and open the hopper orifice enough to throw a stream of fertilizer granules.
9. The swath width of the fertilizer stream relative to the end stakes should be noted by the persons aligned with the stakes.

10. Repeat steps 5-9, adjusting the width of the end stakes such that granules over throw the stakes (in this example) by about 6 feet (effective swath width = $30 \times .60 = 18$ feet or 9 feet to the left and right of the center line). This is the effective swath width. For uniform overlap, the spreader must be operated on passes centered on 18 feet.

Initially the spreader may throw beyond or short of, the end stakes because of differences in the fertilizer material as noted above. It may take several on-off cycles of the spreader to visually estimate the effective swath width. The visual method is less accurate than collection pans, but it's sufficient for all but the most exacting fertilizer applications.

Calculating the **application rate** of large centrifugal spreaders is best accomplished by selecting a convenient weight such as 50 pounds, e.g. the weight of one fertilizer bag, then calculating a test run length. An example how to do this follows.

Problem: A three-point hitch mounted centrifugal spreader throws 34-0-0 (ammonium nitrate) a total width of 30 feet. The 34-0-0 is packaged in 50 lb. bags. How many feet should the tractor travel while one bag of fertilizer passes through the spreader in order to deliver 150 pounds of N per acre?

Solution: The amount of 34-0-0 needed to supply 150 pounds per acre N is given by:

$$\frac{\text{lb. 34-0-0}}{\text{acre}} = \frac{150 \text{ lb. N}}{\text{acre}} \times \frac{1 \text{ lb. 34-0-0}}{0.34 \text{ lb. N}} \quad [\text{Eq.1}]$$

$$= \frac{440 \text{ lb. 34-0-0}}{\text{acre}}$$

Calculate the proportional test area, T:

$$\frac{50 \text{ lb. 34-0-0}}{T} = \frac{440 \text{ lb. 34-0-0}}{43560 \text{ ft}^2} \quad [\text{Eq.2}]$$

$$T = 5000 \text{ ft}^2$$

Calculate the effective swath width:

$$30 \text{ ft} \times 0.60 = 18 \text{ ft}$$

Divide the test area by the effective swath width:

$$5000 \text{ ft}^2 / 18 \text{ ft} = 278 \text{ ft}$$

Stake off a 278 foot test run. Load one 50 lb. bag of 34-0-0 in the spreader hopper. The gate opening that passes one 50 lb. bag of 34-0-0 through the spreader over a distance of 278 feet may be found by trial and error or predetermined based on application rate, ground speed and gate setting information printed on the fertilizer hopper, see **Figure 8**. For example, the application rate for a medium granular fertilizer is listed as 463 pounds per acre for a gate setting of 6 and ground speed of 5 mph. This is close to our target rate of 440 pounds per acre. To test the accuracy of this gate setting, select a gear combination on the tractor for a PTO speed of 540 rpm and 5 mph. Have the tractor operator approach the test run at 5 mph with the spreader gate closed. Then have the operator open the gate as the front axle passes the 0 mark on the test run and close the gate as the front axle passes the 278 foot mark. This should be close to the application rate

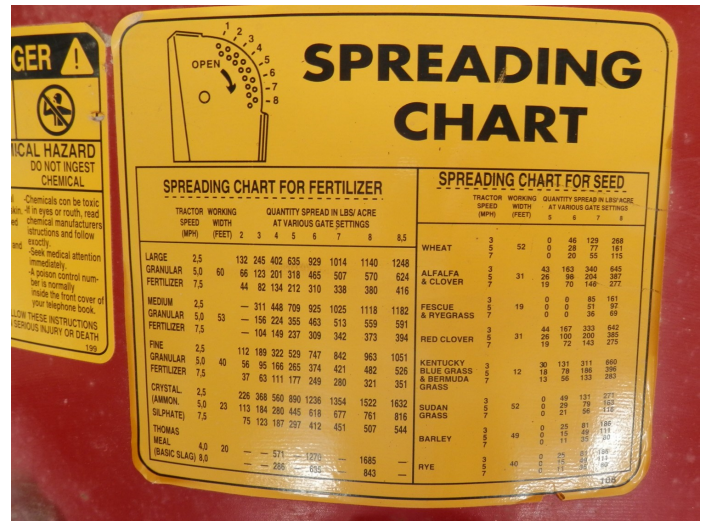


Figure 8. Spreading chart printed on the hopper shows speed, swath width, and gate settings for different fertilizer materials and application rates. For this particular spreader gate settings are adjustable by one-half, which limits accuracy. This spreader also handles grass, alfalfa, and clover seed. Pelleted lime can also be spread but not the powdered type.

needed to pass exactly one 50 lb. bag of 34-0-0 over a distance of 278 feet. If fertilizer ran out before 278 feet, you'll need to close the gate to increase the spreading area. If there was extra fertilizer in the hopper after 278 feet, open the gate to decrease the spreading area.

Don't forget to overlap when doing the actual application. Also, record the gate setting, spreader used, tractor speed, and fertilizer used for future reference. If you change fertilizers, a new calibration will have to be determined for that. Some fertilizer recommendations are given in pounds per 1,000 ft². In this case, simply substitute the 150 pounds of N in Eq. [1] with the fractional N rate given per 1,000 ft² and substitute 1,000 ft² for 43,560 ft² when calculating the proportional test area *T* in Eq.[2].

23.2 CORE INTELLIGENCE

Application rate: The amount of material applied per unit treated. For fertilizer spreaders, the unit treated is land area, in acres or square feet.

Coefficient of friction: A measure of the amount of resistance that a surface exerts on substances moving over it, equal to the ratio between the maximal frictional force that the surface exerts and the force pushing the object over the surface. For example, a corroded spreader impeller blade would have a higher coefficient of friction than a smooth blade.

Effective swath width: The distance between two overlapping broadcast applications measured center-to-center.

Rotary impeller: A metering device that causes material to be displaced unidirectionally from its center axis of rotation at a fixed rate.

Working swath width: The total throw distance of a single-pass broadcast application.

23.3 FURTHER READING

Field, H.L. and J.M. Long. 2018. *Introduction to Agricultural Engineering Technology*. 4th ed. Springer, New York.

Parish, R.L. (undated). Granular spreaders: selection, calibration, testing, and use. Available at:

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Last access: 07 Oct 2022.

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