# Fertilizer Application Technology

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# Calibration: What is it & why do we do it?

- Calibration = process of determining the exact amount of fertilizer that  is applied to a given area when the spreader is opened to a particular setting and operated under given conditions

- Factors which can influence application rates include:
  - Type (formulation) and physical properties of the fertilizer used
  - Speed of application
  - Mechanical differences of each spreader

# Spreader Types

- Drop-Type Spreaders
  - precise application & pattern
  - Less chance of drift, more control of pattern
- Pendulum Spreaders
  - Ability to spread to either side, or both sides, with or without spreading directly behind applicator
- Spinner-Type Spreader
  - Wider swath of coverage, faster application
  - Less uniform distribution, drift can be a problem
- Air-Boom Spreaders
  - Used mainly in larger acreages, very uniform distribution pattern

# Full-width, gravity-flow spreaders (drop type)

1. long V-shaped trough supported by wheels on each end
2. Fertilizer falls by gravity through the holes (gates) in the bottom of the trough
3. Changes in gate size control the rate of application
4. Rotating, ground-driven agitator crushes lumps of fertilizer & aids in keeping material flowing freely & uniformly through the gates
5. Use manufacturer's settings as a starting point in calibration





# Calibrating a Drop Spreader

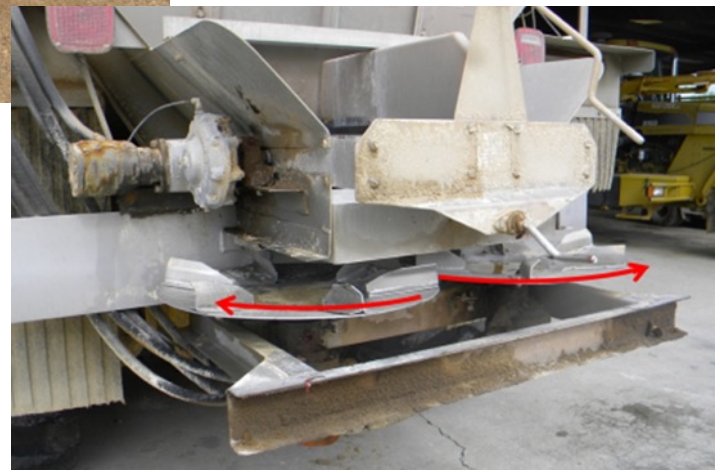
- Measure the width of the hopper (same as the width of the swath)
- Calculate the length of the test strip (assume test strip = 1,000 $ft^2$)
  Ft. to travel for 1,000 $ft^2$ = 1,000 $ft^2$/ width of swath (8 ft.) = 125 ft.
- Fill the hopper uniformly with a known volume or weight of product
- Set spreader at a low to medium discharge or use the manufacturer's suggestion as a starting point
- Traverse the measured course
- Measure the product left in the hopper and subtract this number from the beginning weight find the amount of product discharged by the spreader
- Adjust spreader setting up or down as needed and repeat the process until the discharged amount equals the amount desired for 1,000 $ft^2$

# Central Hopper Broadcast Spreader

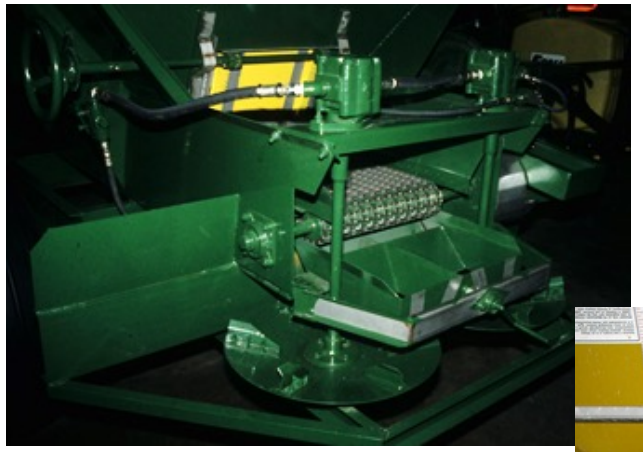
- Most commonly used spreader type
- May be hitch-mounted, pull-type or truck-mounted
- Capacities range from 50 lbs. to 9 tons
- Hoppers made of steel, stainless steel, epoxy-coated steel, fiberglass, polyester & polyethylene

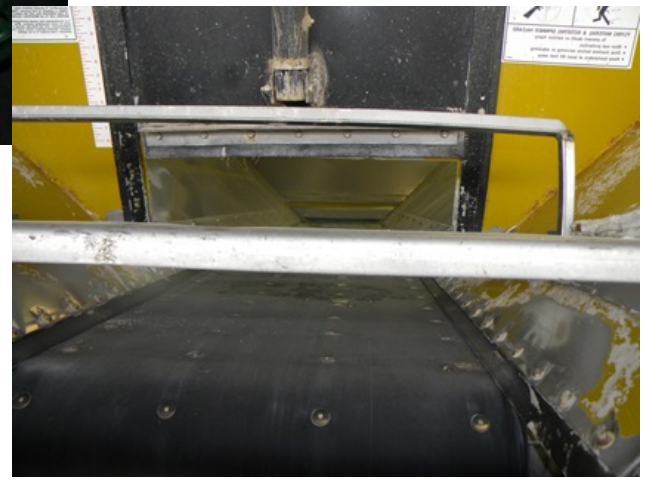
# Central Hopper Broadcast Spreader

- Single or dual centrifugal spinners throw fertilizer over the land surface



- Materials metered from hopper to distributor by use of a drag chain, belt, or simple gravity-flow openings





# Rotary Spreaders

- Also known as centrifugal, spinner, cyclone or broadcast spreaders
- Applies fertilizer by dropping a dry granule from a hopper onto a spinning impeller, which distributes granules by centrifugal force

# Pendulum Spreader

**Spreader**


**Collection box for pendulum spreader**

# Customize Your Pendulum Sprayer

- Electric actuator for the gate
  - Great for use in a cab tractor
- Weather-proof cover for the hopper
  - Lets you spread fertilizer in the rain (so you know the N is going into the ground)
- Capacitive proximity switch
  - Lets you know when the hopper is empty
- S-lite guidance system
  - Has a return-to-point feature that lets you know where to start back after refilling the hopper

# Air-Boom Spreaders

# Spinner Spreaders

## Primary advantages

- Possibility of swath widths up to 60 ft.
- Typical field capacities approach 15 acres per hour
- Direction of distribution cans be controlled (right, left, both sides or full spread)
- Material can be placed up or down slopes, under fences and under and around trees & vines

## Potential problems

- Uneven distribution patterns
- Lack of operator understanding of calibration & adjustment procedures
- Material drift
- Heavy weight of equipment (may need flotation tires, tandem axles, dual wheels)
- Higher initial cost.

# ASAE S341.4 Dec. 2009
# Procedure for Measuring Distribution Uniformity and Calibrating Granular Broadcast Spreaders

- Purpose: establish a uniform method of determining and reporting performance data on broadcast spreaders designed to apply granular materials on top of the ground.
  - Make it possible to:
    - Predict distribution uniformity of the spreader
    - Compare spreader distribution patterns
- Scope:  pertains to centrifugal, pendulum and other types of broadcast spreaders designed for dry granular application while operating on the soil surface.
  - Additional tests needed to determine delivery rate of gravity or drop spreaders
  - Does not cover dry, pneumatic granular applicators

# Goal : Spread the **proper amount** of material **uniformly** over the soil.

- Measure the amount of material being metered from the hopper in a given amount of time or as a known area is covered
  - The actual fertilizer to be applied should be used
    - Different fertilizers will require new calibrations.
  - Calibrate in the field where the fertilizer will actually be applied
  - Use the same gear and throttle setting as will be used in the actual fertilizer application

# Test Conditions

- Spreader shall be:
  - in good mechanical condition
  - properly adjusted
- Tests may be conducted to:
  - Verify distribution uniformity
  - Adjust for a specific granular material being spread under conditions similar to actual field conditions
- Tests should be conducted with:
  - a standardized test material (uniform size spherical prills)
  - a specific granular product
  - or an inert product simulant

# Test Procedure – guidelines for setup

- <u>Accuracy of test may be influenced by:</u>
  - Wind
  - Granule or particle size
  - Critical relative humidity of the product
  - Rate of application
  - Ground slope
  - Travel speed
  - Ground roughness
  - Temperature
  - Relative humidity
  - Method of collecting samples

# Test Conditions:

- Tests should be conducted over the same or similar ground conditions on which fertilizer will be applied.
  - Conducting tests on a hard surface can affect:
    - Particle bounce into collection devices, which can impact
      - Effective swath width
      - Rate and pattern uniformity
- Fill the spreader within 4 hours of testing
- Run the spreader with the hopper or box filled and leveled to 40% to 50% of capacity as defined by ASAE S281

# Collection Devices

- Width of each collecting tray (measured perpendicular to the direction of travel) shall not exceed 10% of the anticipated effective swath width
- Length shall be equal to or greater than the width with a minimum length of 30 cm (1 ft.)
- Maximum wall thickness of tray – 2.3 mm (0.09 in)
- To decrease the possibility of particles ricocheting out of trays, each tray should be divided into compartments with a MAXIMUM size of 10 cm (4 in.) wide by 10 cm ( in.) long and a MINIMUM size of 5 cm (2 in.) wide and 5 cm (2 in.) long.
- Depth of the compartments  shall be at least 50% of the maximum horizontal dimension

# Collection Devices

- Sufficient trays shall be used to:
  - Provide at least 10 trays within the effective swath width
- Spacing of trays:
  - Uniform
  - Rearrange or omit trays to provide space for spreader and vehicle wheels
  - Additional trays should be spaced out on either side of the anticipated swath width to a distance equal to at least 50% of the swath width on each side
- Tops of the trays shall not be more than 10 cm (4 in.) above the ground level with the spreader in the normal operating position.
  - If the height of the discharge point on the spreader is less than 0.5 m (20 in.), tops of the trays shall not be over 5 cm (2 in.) aboveground

# Spreader Operation and Travel Speed

- PTO driven units shall be operated at the speed specified by the spreader manufacturer
- For truck mounted units, the spinner shall be rotated at the speed recommended by the manufacturer
- For electrically driven units, supply voltage shall conform to that recommended by the manufacturer
- Relative travel speed between the spreader and the collection tray shall be in the range recommended in the manufacturer's literature and shall be kept constant during the conduct of the test

# Test Procedure (2 parts)

1. Determination of application rate
2. Determination of the distribution pattern by measurement of applied materials from collectors

- Replication of each part of the test will help account for random variability and increase the accuracy of the test.

# Determining Rate of Application

- Attach a tub or similar receptacle under the delivery chute
- Depending on the spreader, detach or disengage the spinners
- Measure and mark a 200 foot course in the field to be fertilized
- Simulate application by driving the spreader over the course with the conveyor engaged
  - Use the same gear and engine speed as will be used when distributing the fertilizer
  - Get up to speed before crossing the “starting line” and continue past the “finish line” of the course before starting the spreader and shutting it down, respectively.
- Remove and weigh the fertilizer collected in the tub.
- Convert the pounds of fertilizer collected to pounds per acre.
  - Lb/acre = $\frac{\text{lb. collected X 43,560 ft}^2\text{/acre}}{\text{(swath spacing in feet) X (length of test run in feet)}}$

# Adjusting the Rate to be Applied

**To increase rate of application**

- Increase the feed gate opening
- Increase the speed of the metering device and/or
- Lower ground speed

**To decrease rate of application**

- Decrease the feed gate opening
- Decrease the speed of the metering device and/or
- Increase ground speed

Repeat the Rate of Application Determination steps

# Determining Application Rates

- Preferred method: measuring the amount of material exiting the spreader during operation over a known area.
  - Determine weight of material applied by collecting and weighing spreader output while traveling a measured distance

    or

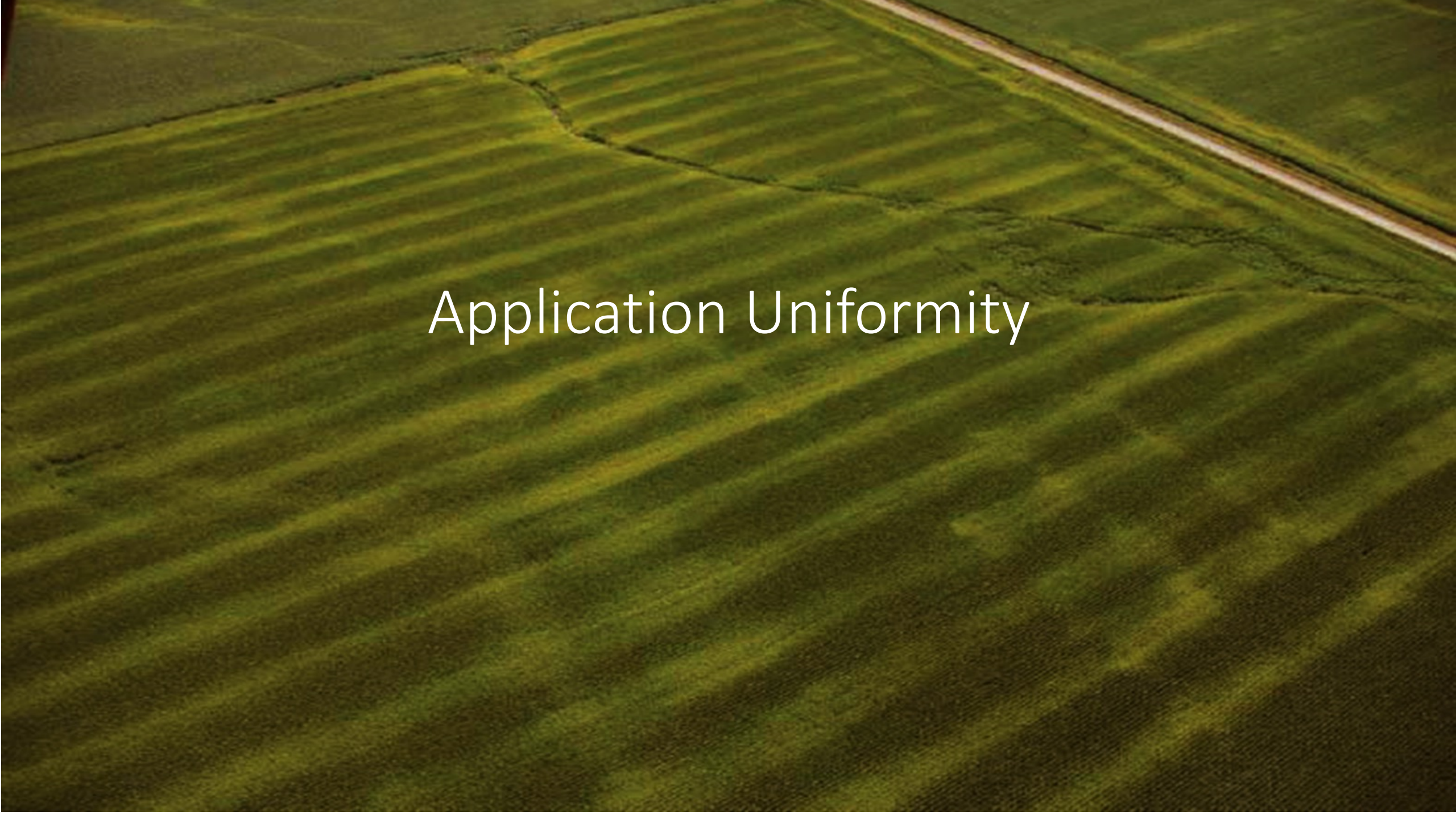
  - Weigh the spreader and contents before and after spreading material over a known distance.
- Plug information into the formula: R = QK/LW
  - R = application rate (kg/ha, lb./acre)
  - Q = mass applied (kg, lb)
  - L = distance spreader operated (m, ft)
  - W = swath spacing (m, ft)
  - K = constant (10,000, 43560)

# Determining Application Rate (Alternative Method)

- Calculate from the amount of material collected from the spread pattern test.
  - Accuracy is influenced by the collector design and the type of surface around the collectors.
  - Use the following equation (assume 100% collector efficiency unless otherwise known – R=KW/AE
    - R = application rate (kg/ha, lb/acre)
    - K is a constant (100,000 (13,829))
    - W = sample mass
    - A = area of collector opening
    - E = collector efficiency(usually 0% to 100%

# Determining Application Rate Using Volume of Material Collected in Spreader Pattern Test

- Use the formula, W = DV/K, where:
  - W = mass (g)
  - D = bulk density (kg/m³, lb/ft³)V = volume (cm³)
  - K = constant (1.000 (62.4)


Application Uniformity

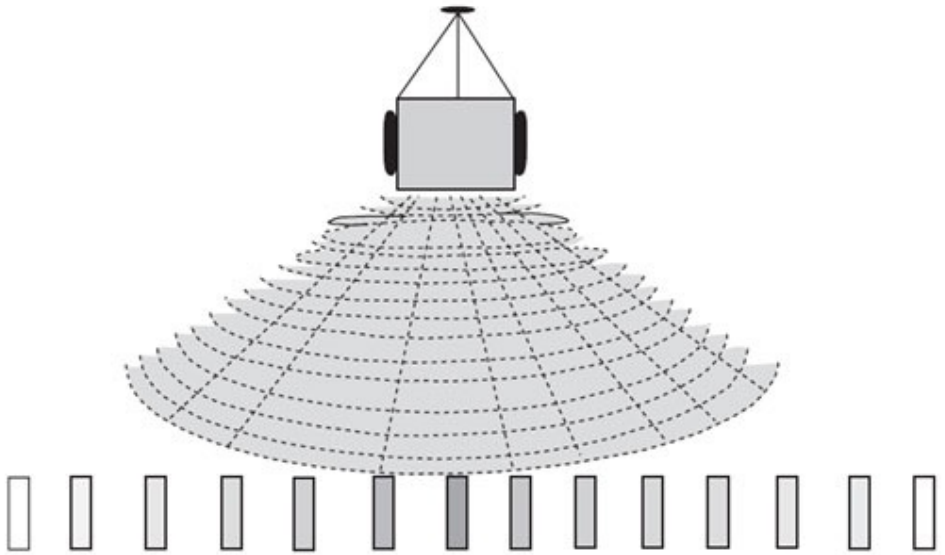
# Spread Pattern Test

- Indicates the degree of uniformity of distribution of material across the swath being spread.
- Accomplished by operating the spreader in a line perpendicular to a line of collection trays spaced equally on the ground
  - Use an odd number of trays
  - Drive the spreader astride the center pan.
  - Material in each tray should be weighed or measured volumetrically .
  - If multiple rates are to be used, select 25%, 50% and 75% of the maximum application rate

# Uniformity of Distribution

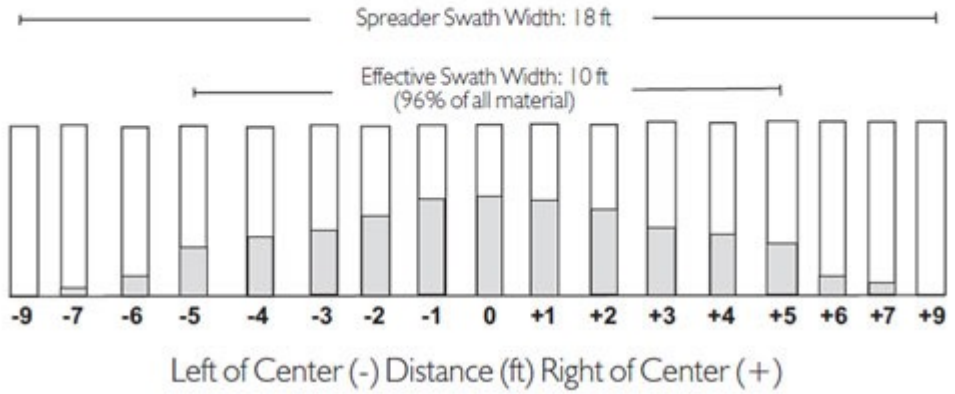
- Coefficient of variation (CV) shall be used to determine & express the uniformity of distribution of applications.
- When overlapping of swaths occurs, a simulated field application of multiple adjacent swaths  shall be used to compute the CV.
  - The simulated field version for each swath width to be evaluated is to be constructed by accumulating the sample weights from the simulated overlapping swaths at each collection tray location.
  - Individual replicates of the swath distribution pattern (not averages) shall be used.
  - Method of spreading used should be reported
    - Progressive (back and forth)
    - One direction (racetrack)

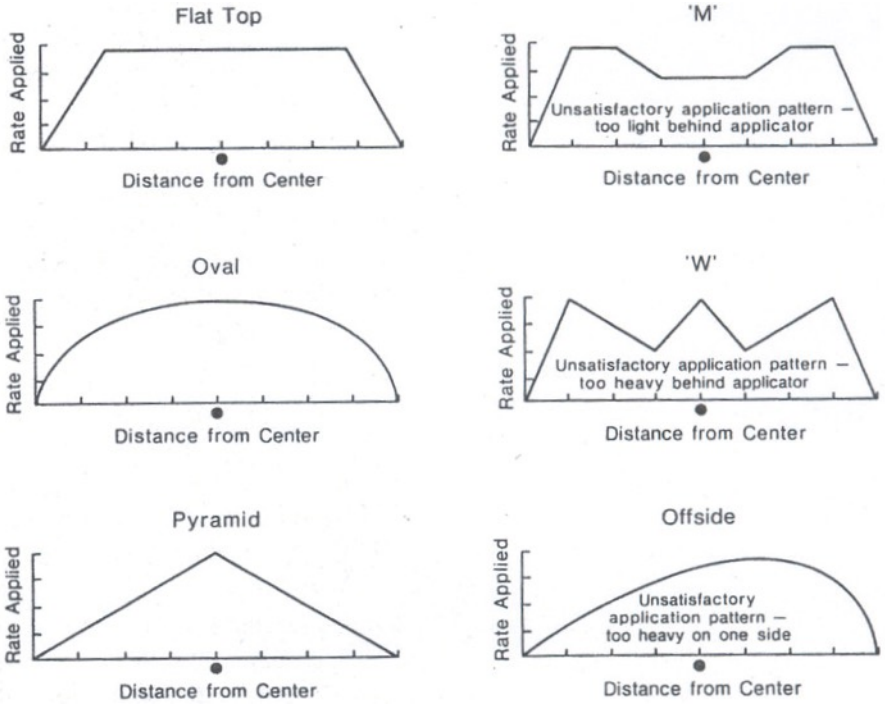
**FIGURE 3.** Check rotary spreader swath width and material distribution patterns using equally spaced containers (ice trays, empty egg cartons). Color of the collection trays is directly proportional to the amount of material collected (darker = most material).

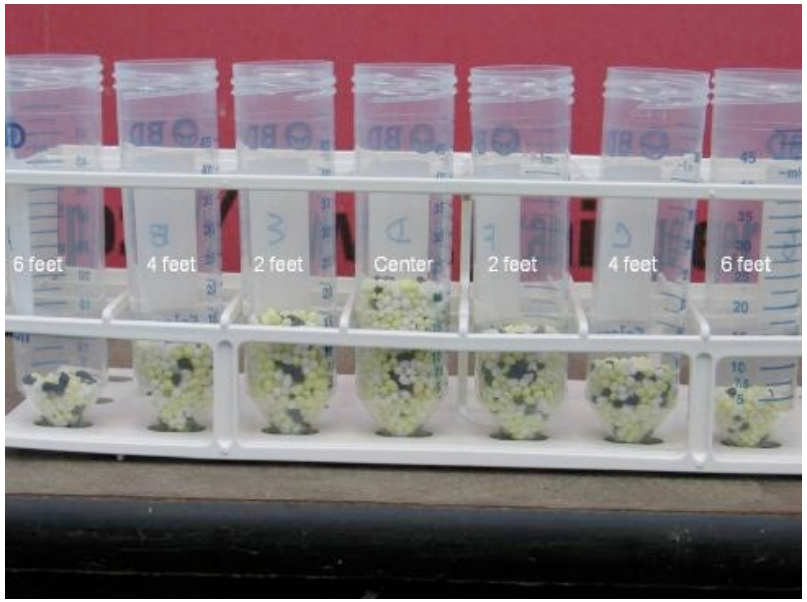


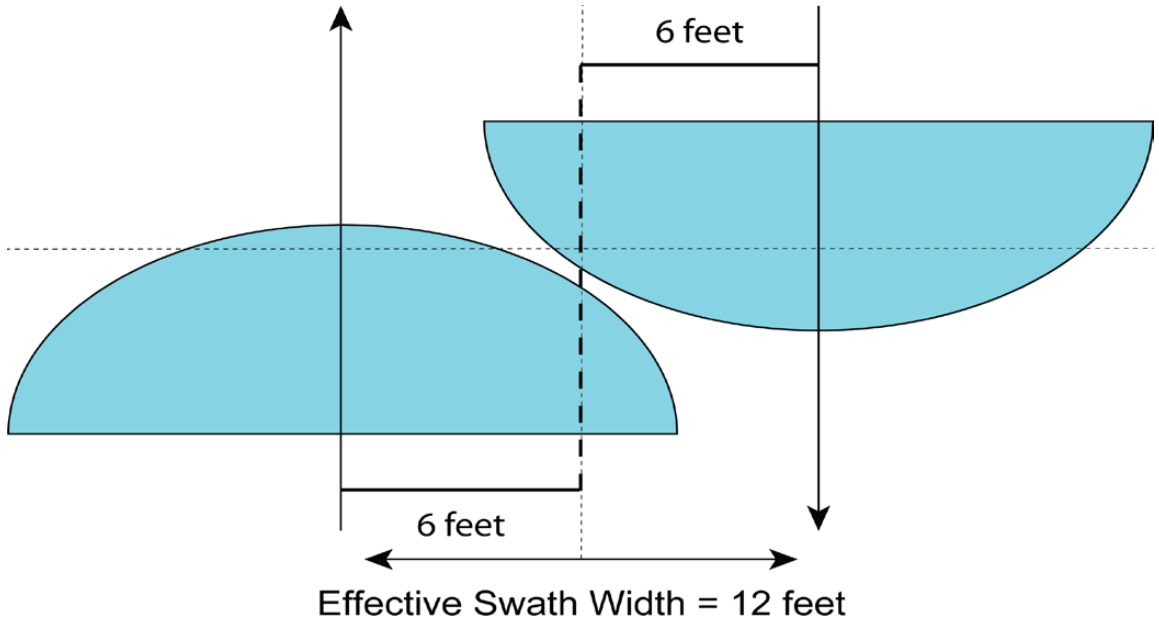
# Uniformity of Distribution

**FIGURE 4.** Actual fertilizer material distribution pattern using a rotary spreader and a 19-19-19 fertilizer.

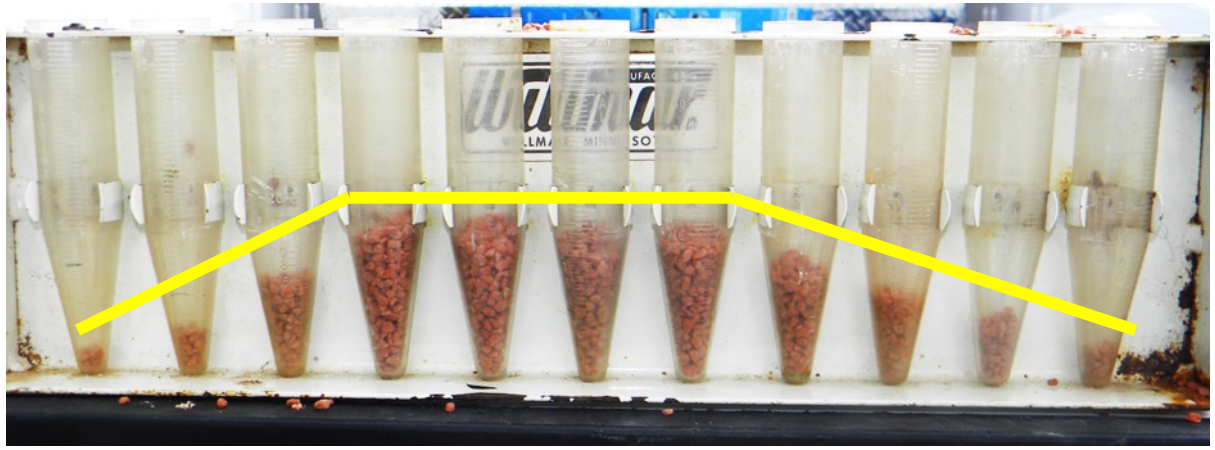


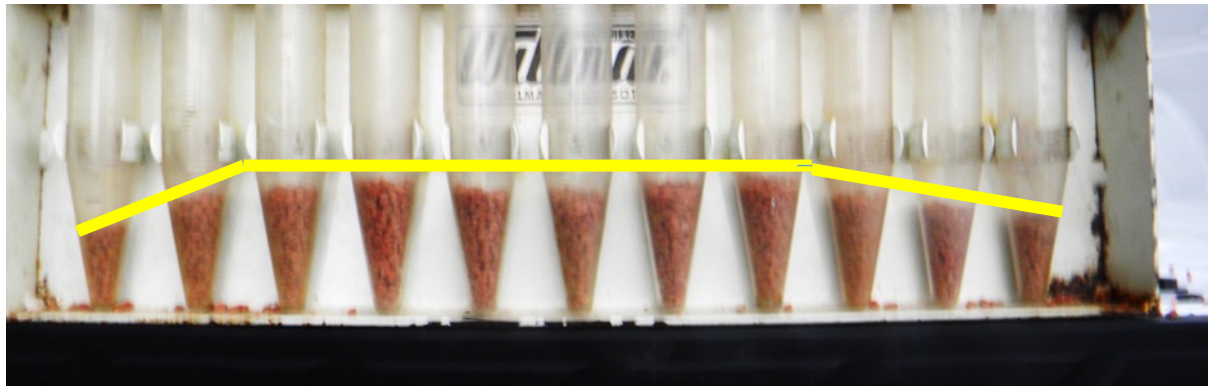

6 feet
4 feet
2 feet
Center
2 feet
4 feet
6 feet


6 feet
6 feet
Effective Swath Width = 12 feet

Spinner spreader needs fans away from conveyor



Spinner spreader needs fans moved toward conveyor



Ideal spinner spreader

# Variables Affecting Accurate Product Delivery:

- Spreaders – even the same make and model
- Spreader maintenance
- Product label – spreader setting on prduct label may be used as a starting point for calibration
- Granular particles – variations in density, size, active ingredient and nutrient content
- Ground speed – rate of material delivery may remain constant , but varying speed will impact size of application swath

# Steps in Rotary Spreader Calibration

1. Determine the size of the area to be fertilized
2. Measure the spreader's effective swath
    1. Fertilizer is not delivered uniformly over the entire width of the swath
        1. Adjacent passes must overlap by  30 to 50%

# Calibrating Your Fertilizer Spreader
# Penn State
# Step 1: Materials Needed

- Fertilizer Spreader
- Tape measure
- Scale – one that will weigh small amounts of fertilizer (ounces) accurately
- Bucket
- Chalk or flags
- Calculator, pencil, paper

# Step 2: Measure the spreader's effective swath width

- Place shallow pans or boxes (1 $ft^2$ X 1 or 2 inches high one foot apart in a row that is wider than the anticipate spreader swath
  - Be sure to leave enough space between the center pans to allow room for the spreader to pass
- Fill the spreader about ½ full with the material you intend to apply
- Select the spreader setting recommended on the label of the fertilizer bags as a starting point
  - Spreader swath will vary with the spreader model, the product used and the ground speed on ground-driven spreaders
- Travel in a direction perpendicular to the pans
- Begin well in front of the line of pans
- Travel at a comfortable speed, passing over the pans.
- Make at least 3 more passes going in the same direction

# Step 2: Collect pans and record weights

- Record the location of each pan in relation to the distance from the center pan
  - Example: 1 = first pan on the right side of the center pan, -1 = first pan on the left side of the center pan
- Weigh the contents of each pan and record the weights

# Step 2: Compare Weights

- Weights are typically highest near the center of the row of pans and taper off as the distance from the center pan increases
- When the weight of fertilizer from pans on the left and right sides of the center pan equals half the weigh to the center pan, measure the distance between these pans.  This distance is the effective swath width
  - If the effective swath width for a given fertilizer is 10 feet, then passes when spreading this fertilizer should be 10 feet apart

- Step 3: Measure a course 50 to 100 ft. long over which to run spreader
- Step 4: fill hopper 1/3 to ½ full with a known weight of the fertilizer to be used (record this weight)
- Step 5: Adjust spreader to the recommended setting on the fertilizer bag (if no rate is listed, select a low to medium rate on the spreader)
- Step 6: Beginning several feet in front of the starting line, get up to the desired speed for fertilizer application, open the hopper as you pass the starting line and shut it off when you pass the finish line
- Step 7: Pour the remaining fertilizer from the spreader into a bucket and weigh it (be sure to subtract the weight of the bucket). Subtract this weight from the beginning weight to determine how many pounds of fertilizer were distributed.

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- Step 8: If the fertilizer distributed does not match the desired output, readjust the spreader setting up or down and repeat the trial run.