UNIFORM LIME AND FERTILIZER SPREADING

by

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Decisions on lime and fertilizer should be based on soil testing, plant analysis, and or reasonable yield goals. On most farms, the desired amount of fertilizer and/or liming material is probably being applied to each field; however, it is also likely that when a portion of the dry fertilizer is broadcast on the soil surface, it may not be spread uniformly over the field. Because of this uneven distribution, farmers can end up wasting money on unnecessary amounts of lime and fertilizer.

Uneven distribution of lime and fertilizer can also reduce crop yields. Research indicates that when one area of the field is over-fertilized and another is under fertilized, the total yield typically will be less than if the correct amount of fertilizer were spread evenly over the entire field. The reason for these findings is due to the law of diminishing returns. The law of diminishing returns states that there will be a decreasing return for each additional increment of fertilizer applied (Figure 1). In attempting to obtain maximum yields, the last increment of fertilizer applied will increase the yield by a smaller amount than the previous increment. Therefore, a given amount of fertilizer on an under-fertilized part of the field will result in a much larger yield increase than that same amount of fertilizer applied to an over-fertilized portion of the field.

The effects of variability in fertilizer distribution are most notable on soils with low to medium fertility. On soils with medium to very high fertility, the response to fertilizer is not as great, and detrimental effects due to uneven spreading are not as noticeable. On soils with low to medium fertility, the response to fertilizing and liming is larger, and the effects of uneven distribution are much more noticeable. Studies conducted in Virginia at two locations, one with low soil fertility and one with high soil fertility, demonstrated the effect of fertilizer distribution patterns on wheat yield (Fig. 2). On the low fertility soil, maximum yields of wheat occurred where the fertilizer had been spread uniformly. On the high fertility soil, fertilizer-spreading pattern had little impact on wheat yield.

In cases where the fertilizer had been applied to the low fertility soil in a non-uniform pattern, yields were reduced by 20 to 25 percent (Fig. 2). On the more fertile soil, yields were not obviously affected by the various spreader patterns since little or no response to fertilizer occurred. A similar response was obtained in that non-uniform application of fertilizer resulted in less total yield that uniformly applied fertilizer (even though the same total rate per acre had been applied in each case).

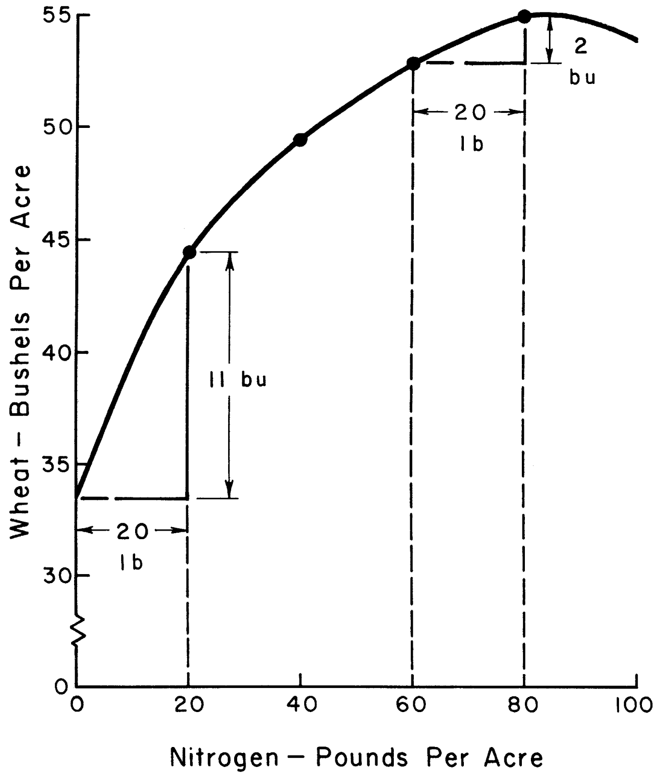

Figure 1. The response of Arthur Wheat (Poplar Hill Farm - 1973) to varying rates of nitrogen fertilizer.

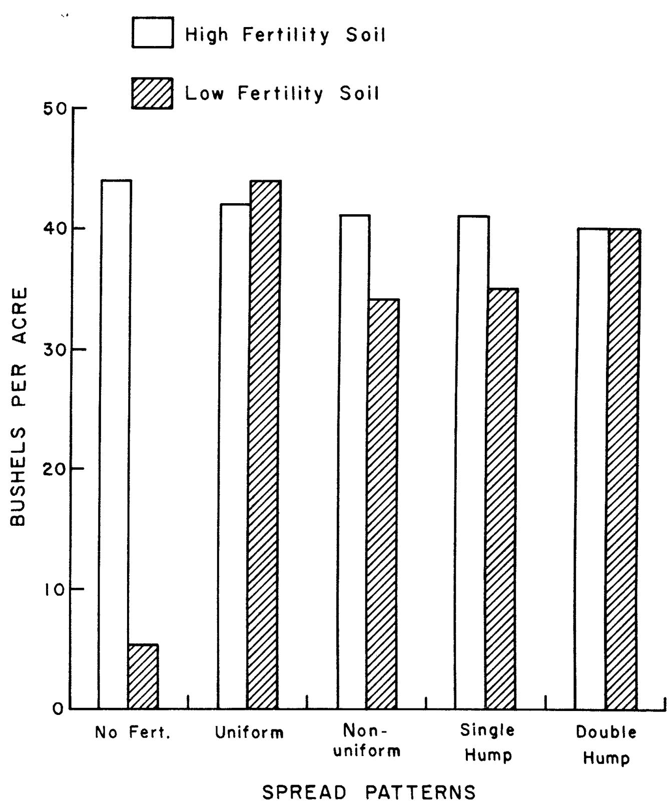

Figure 2. The effect of fertilizer spread patterns on the yield of wheat (VPI & SU, 1970).

Obviously, the effects of non-uniform nutrient distribution on medium to high fertility soils will not be as apparent as on low to medium fertility soils. However, non-uniform soil fertility differences are likely to develop, particularly if similar non-uniform spreader patterns are followed year after year. Such continued poor practice can also make it difficult to obtain a good soil sample for fertility evaluation.

According to the 2002 University of Maryland Soil Test Summary, 41 percent of the agricultural fields tested in Maryland had a pH of 6.0 or lower. In some counties, as high as 62 percent of the samples tested had a pH of 6.0 or lower, indicating a great need for lime. It is on these low pH fields that the greatest amount of damage can occur due to non-uniform spreader distribution patterns.

Similarly in some counties, as many as 31 percent of phosphorus tests, 13 percent of magnesium tests, and 11 percent of potash tests indicated low fertility levels. These fields will suffer the greatest yield reduction due to non-uniform spreading. On higher fertility soils, poor lime and fertilizer distribution apparently may result in smaller reductions in yield. In many cases soils that are high in phosphorus and potassium can be damaged if the pH is too high. Soil pH that is too high may result in reduced nutrient availability and subsequent plant nutrient deficiencies (e.g. manganese).

In the spring, evidence of spreading problems is often found on pastures, which have been top-dressed with nitrogen. As the growing plant starts to turn green in the spring, fertilizer spreader patterns become obvious. Where uniform spreading jobs have been done, the field will be evenly green. With non-uniform spreading, streaks of light and dark green will be visible due to the uneven rates of fertilizer application.

Spreading problems can occur with both lime and fertilizer materials on farm fields, as well as on home lawns and gardens by using different kinds of spreaders including spinner, boom, and full-width types. For instance, applicators ideally should be calibrated for each kind and rate of material applied. Equipment operators, whether hired or are spreading on their own fields, usually learn very quickly how to adjust their spreaders to distribute the correct amount of material per acre. Only exceptional operators seriously consider and analyze the factors that can cause more material to be delivered to one side of the swath than to the other, how far the material may be thrown to one side, and the variations in swath width.

This publication will:

- describe the different types of spreading equipment currently in use and how they work;
- discuss the measurement of distribution patterns produced by these spreaders;
- discuss some of the factors which cause non-uniform distribution of lime and fertilizer; and
- describe operating procedures, which can minimize the problem of non-uniform distribution.

Broadcast Spreaders for Lime and Dry Fertilizer

Most farm-owned spreaders for lime and fertilizer are either full-width hopper broadcast spreaders or central-hopper broadcast spreaders. Other similar equipment found on farms includes row-crop units for planters and cultivators and grain drill attachments.

Other machines, which are used more commonly on a custom, rental, or loan basis, include trailer-type bulk spreaders, bulk spreader trucks, and aircraft spreaders.

Full-Width Spreaders

The simplest spreader is the full-width, gravity-flow type, which is a long V-shaped trough supported by wheels on either end. Fertilizer falls by gravity through holes (gates) cut in the bottom of the trough. Changes in gate size control the rate of application. A rotating, ground-driven agitator crushes lumps of fertilizer and aids in keeping material flowing freely and uniformly through the gates.

Advantages of the gravity-flow spreader are:

- low profile to minimize draft, aid filling, and permit operation in low clearance situations; and
- scatter board, which can be used to produce a uniform, full-width sheet of fertilizer over the application area.

Disadvantages of the gravity-flow spreader are:

- application rate is not linear with ground speed (greater rates are applied at lower speeds);
- effective field capacity is low (a 10-feet unit with a 15 cubic feet hopper will cover about 4 acres per hour); and
- maneuverability around objects is poor.

Central-Hopper Broadcast Spreaders

The most commonly used spreader is available in a variety of sizes, hopper materials, and configurations. Units available are hitch-mounted, pull-type, or truck-mounted, with capacities ranging from 50 pounds to 9 tons. Steel, stainless steel, epoxy-coated steel, fiberglass, polyester, and polyethylene are all hopper materials.

Most of these spreaders use single or dual centrifugal spinners to throw fertilizer particles over the land surface. Others use high-speed belts, blowers, or oscillating pendulums as applicators. Truck-mounted units use spinners or booms for distribution. The booms utilize drag chains, belts, or augers in conjunction with adjustable cut-off gates to release fertilizer the entire length of the boom.

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

Spinner Spreaders

Because of their widespread use, the remainder of this publication will concentrate on spinner-type spreaders. The primary advantages of spinner spreaders include:

- possibility of swath widths up to 60 feet;
- typical effective field capacities approach 15 acres per hour;
- variable swath width;
- direction of distribution can be controlled (right, left, both sides, or full spread); and
- materials can be placed up or down slopes, under fences, and under and around trees.

Problems associated with spinner spreaders include:

- uneven distribution patterns;
- lack of operator understanding of calibration and adjustment procedures;
- material drift;
- heavy weight of equipment (fertilizer must be offset by flotation tires, dual wheels, or tandem axles); and
- higher initial cost.

The Distribution Pattern

The simple objective when broadcast spreading lime and fertilizer is to distribute the proper amount of material uniformly over the soil. As a first step in determining the distribution pattern, it is necessary to calibrate the spreader to determine how much of the material is actually being delivered. Although manufacturers usually give directions for equipment settings for different materials and application rates, the best way is to measure the amount being metered from the hopper in a given amount of time or as a known area is covered. The actual fertilizer material should be used in the calibration. If a different material is used, a new calibration should be done. A suggested calibration method would be as follows:

1. Attach a tub or other convenient receptacle under the delivery chute. On some spreaders the spinner(s) are easily detached. On others, the spinner may remain mounted but disengaged by removing the drive chain.

2. Measure and mark a 200-feet course in the field to be fertilized. Drive the spreader over the course with the unloading conveyor engaged. Use the same gear and forward speed, which will be used when actual application takes place.

3. Remove and weigh the contents of the tub. To convert pounds of fertilizer collected to pounds per acre, multiply the pounds collected by the appropriate number (Table 1).

Table 1. Conversion factors for converting pounds of fertilizer collected to pounds per acre.

Swath Spacing (feet)	Multiply pounds collected in 200 feet by
18	12.10
20	10.89
22	9.90
24	9.08
26	8.38
28	7.78
30	7.26
32	6.81
34	6.41
36	6.05
38	5.73
40	5.45
42	5.19
44	4.95
46	4.73
48	4.54
50	4.36
52	4.19
54	4.03
56	3.89
58	3.76
60	3.63

These multipliers come from the following formula:

$$\text{Pounds per acre} = \frac{(\text{pounds collected}) \times (43{,}560 \text{ square feet per are})}{(\text{swath spacing in feet}) \times (\text{length of test run in feet})}$$

If the spreader is operated at normal speeds and the fertilizer used in the calibration is the same as what is being spread, the results will give the correct adjustment needed in order to reach the desired delivery rate. If the calibration shows that an inadequate amount of material is being delivered, one or more of the following adjustments can be made:

- increase the feed gate opening;
- increase the speed of the metering device; and/or
- lower the ground speed.

If excessive amounts of fertilizer or lime are being applied:

- decrease the feed gate opening;
- decrease the speed of the metering device; and/or
- increase the ground speed.

Once it is known that the correct quantity of material is being applied, the uniformity of the distribution pattern across the swath must be assessed.

The uniformity of a field pattern depends upon the location of the spread pattern center-line and the uniformity of the spread pattern itself. The traditional method for evaluating a field machine uses a series of trays placed on the ground in a line perpendicular to the direction of travel (Fig. 3). One or more passes of the spreader in the same direction deposits material in the trays. A plot of the material weight from each tray versus the location of the tray gives a visual picture of the distribution pattern. Kits available for this calibration include a set of plastic or glass cylinders (or test tubes). Material from the trays is poured into the tubes in order, and the height of fertilizer in the tubes assists in visualizing the spread pattern (Fig. 4).

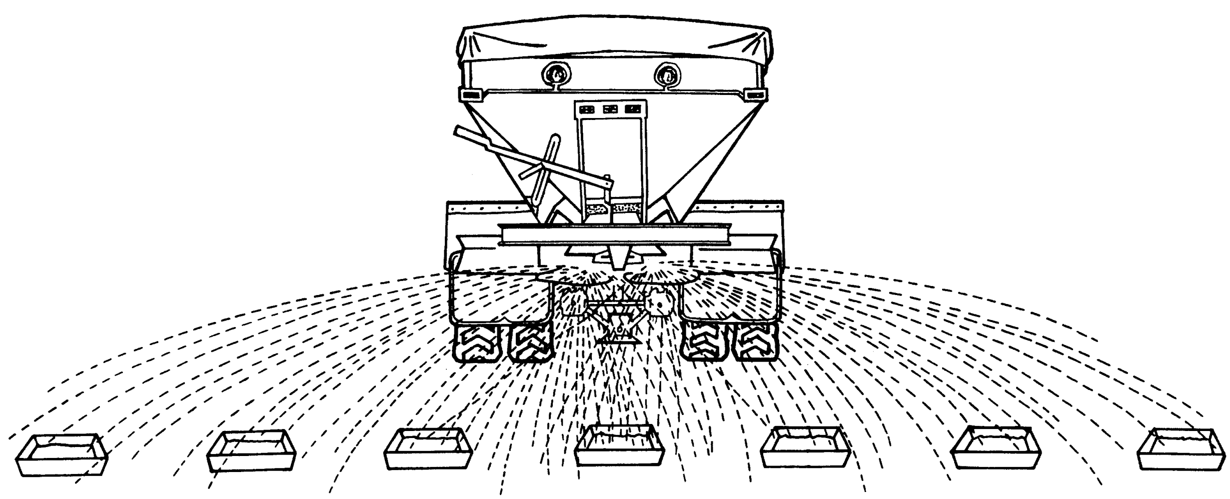

Figure 3. The tray system for evaluating spreader distribution pattern.

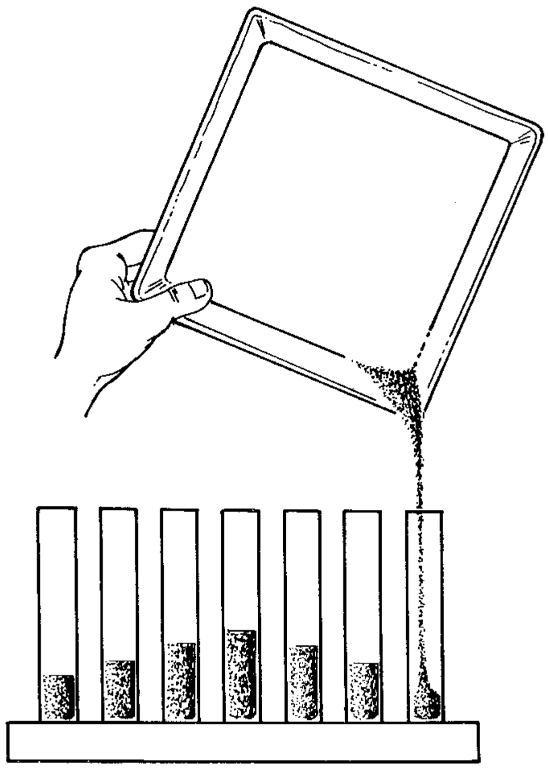

Figure 4. The spread pattern is easily seen when the trays are emptied into tubes.

Theoretically, the ideal distribution pattern for a broadcast spreader is shown in Figure 5. The visual picture is a flat-topped, trapezoidal pattern with uniform sloping sides. Since there are equal amounts of material on each side of the spreader centerline, subsequent passes of the equipment would overlap adjacent spread patterns halfway up each respective side of the graph.

Most broadcast spreaders actually produce a distribution pattern as shown in Figure 6. The oval that results produces a rather large span in the center of the pattern where the material is uniformly distributed, but this drops off at the ends of the swath. Effective coverage with this pattern is about 60 percent; that is, about 20 percent of the swath width must be overlapped in subsequent passes in order to produce uniform distribution. For example, an oval pattern 40-feet in width would have an effective width of 24 feet. Overlap of 8 feet would be required in subsequent passes.

A large number of spreaders produce the pyramid pattern shown in Figure 7. Although this is an acceptable pattern, the effective swath width is only about 50 percent of the theoretical swath width. For example, instead of 40-feet swath center spacing, 20 feet is the maximum possible for uniform distribution. The result is reduced field efficiency in that greater time is required per acre.

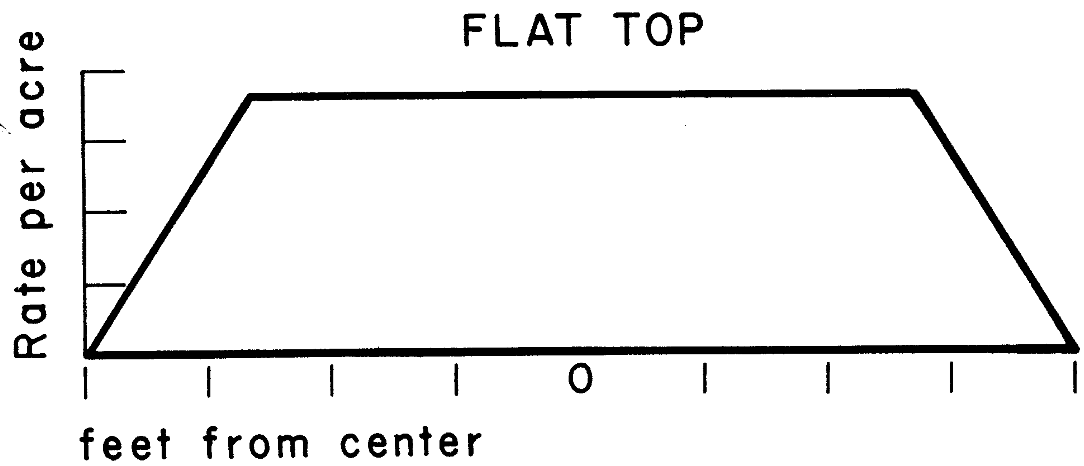

Figure 5. The ideal fertilizer spread pattern.

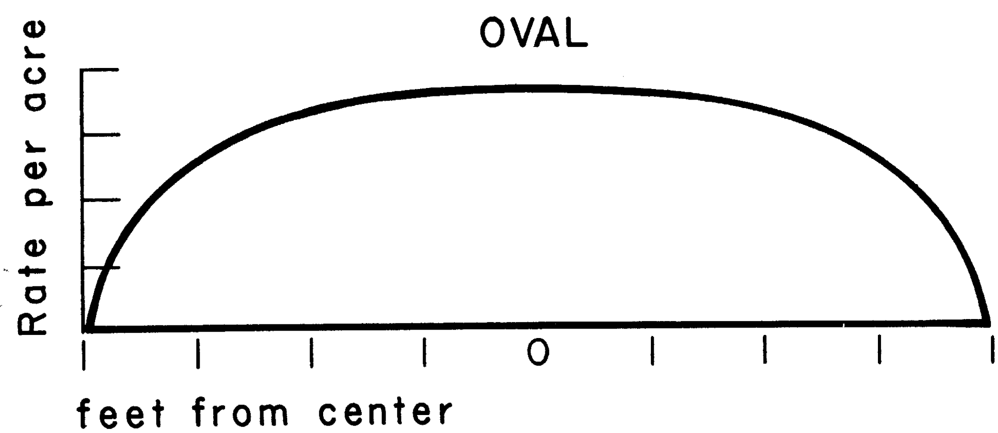

Figure 6. The normal spreader distribution.

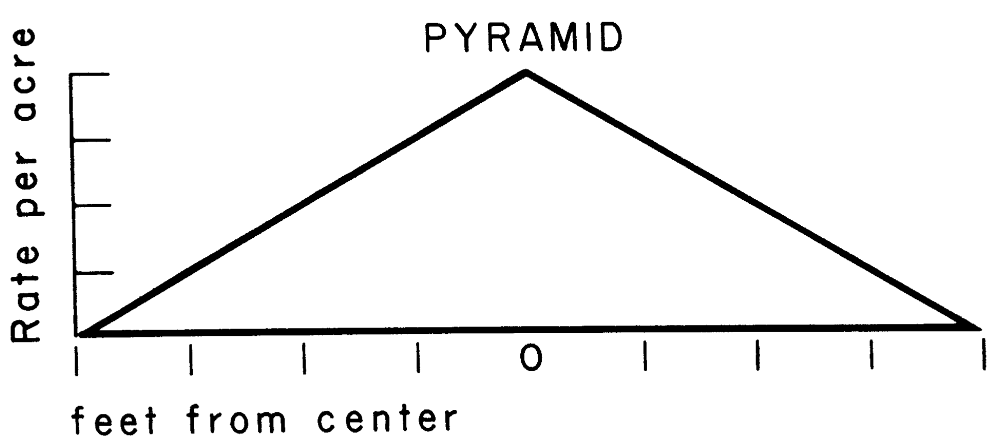

Figure 7. An acceptable distribution pattern.

Poor Spreader Problems

Poor spreader patterns can be caused by:

- a malfunctioning spreader
- inexperienced operator
- incorrect swath width due to fertilizer particles
- moisture content of the material being spread
- slope of the land
- incorrect ground speed synchronized with discharge rate
- driving pattern not adapted to the shape of the field
- poor conditions such as rough, uneven terrain

Three examples of poor spreader patterns are shown in Figure 8.

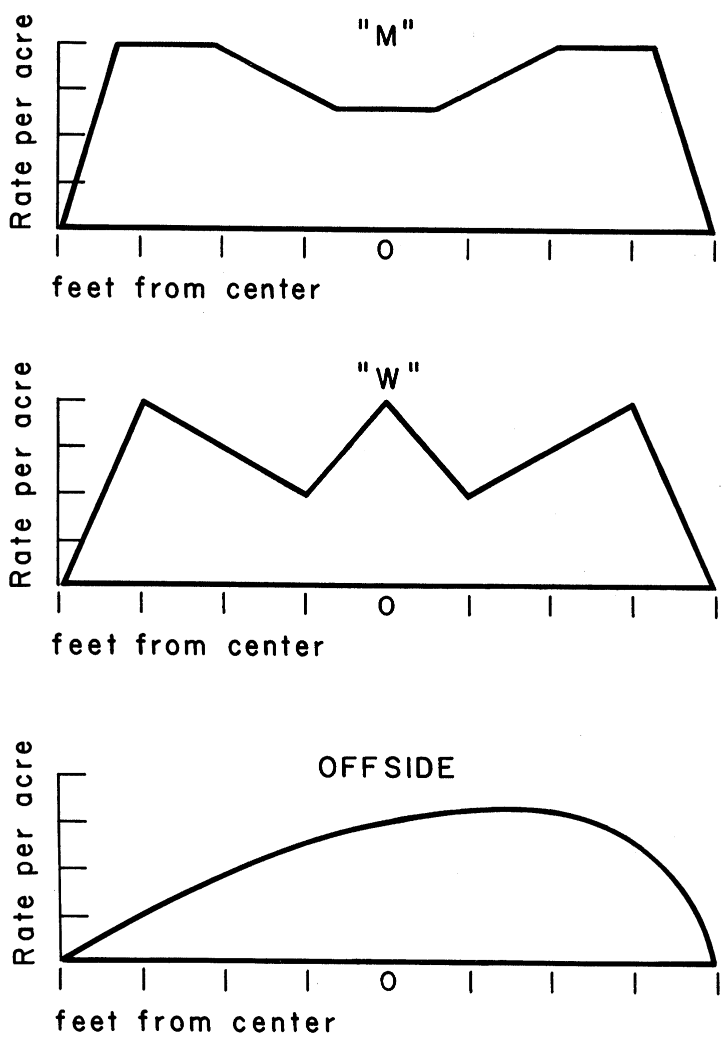

Figure 8. The three major problem-type spreader patterns.

The most common problem is the offside pattern with excessive material placed on one side of the centerline. Another problem is the “W” pattern with three areas of high material concentration. The “M” pattern produces too little fertilizer or lime directly behind the applicator machine. The “W” and “M” patterns are usually associated with twin-spinner spreaders. Many times the “W” and “M” are also offside, which complicates correction of the problem. Such patterns must be corrected before continuing to apply fertilizer or lime. Overlapping on “W” or “M” patterns only doubles the material where too much as already been spread.

In order to correct spread patterns, refer to Figure 9. Adjusting the point of fertilizer delivery, blade pitch, or spinner spreader may be necessary to correct the pattern.

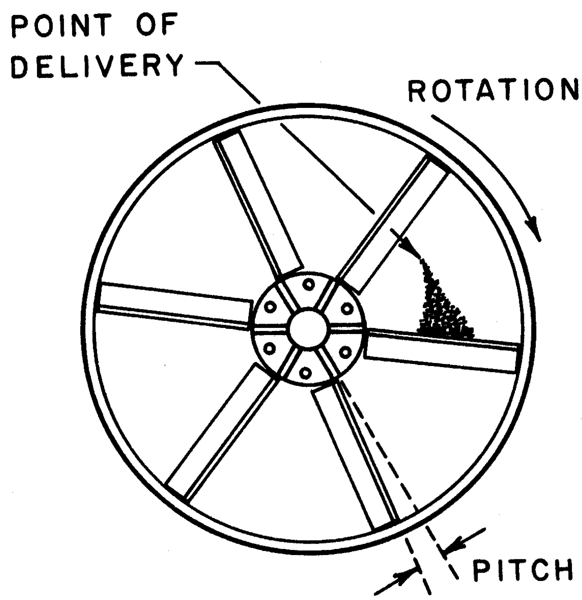

Figure 9. Adjustment of point of fertilizer delivery, blade pitch or spinner speed may be necessary for uniform distribution.

For example, if the right half of the pattern (as viewed from behind and above the spinner) from a clockwise-rotating, single-spinner is heavier than the left half, any of the following adjustments will delay the release of fertilizer from the spinner and correct the pattern:

1. Move the chute to shift the point of delivery in a clockwise direction.

2. Move the point of delivery closer to the center of the spinner.

3. Move blade tips forward in the direction of the spinner rotation.

4. Decrease the spinner speed.

If the left half of the pattern is heavier, make the adjustment in a direction opposite to those indicated.

With twin-spinner distributors, the counter-rotating spinners must start unloading at the proper time to provide uniform coverage directly behind the machine. If application directly behind the spreader is too light, such as with the "M" pattern, earlier release of fertilizer from the spinners will correct the pattern. To do this, make at least one of the following adjustments:

1. Move the chute to shift the points of delivery in a direction opposite to the direction of the individual spinner rotation.
2. Shift the points of delivery closer to the periphery of the spinners.
3. Move blade tips back in a direction opposite to the direction of individual spinner rotation.
4. Increase the spinner speed.

If the pattern is offside on a twin-spinner, the flow divider must be positioned to deliver equal amounts of material to each spinner. Spinner spreaders work best when the hopper discharge chute extends down near the spinner.

Even with proper adjustment, not all dry blends of fertilizer materials can be uniformly distributed across the swath. For uniform distribution without segregation of the ingredient materials, it is important that particle size and density of materials be closely matched. Because the distributor action is conducive to segregation, this precaution should be observed regardless of whether the materials are blended by a stationary bulk blender or a compartmented blending truck.

Skilled Operators

Any operator must know the effective swath width covered by his spreader before he can drive accurately and space swaths correctly in the field. The skilled operator measures the effective swath width covered by the spreader and knows what spacing to use. Some operators guess and frequently use incorrect spacing. Use of the tray system makes it possible to know just how far the material is being spread. Since swath width tends to increase with higher spinner speeds, it is important that checks be made with the spinner operating at field speed.

Safety Precautions When Handling Fertilizers

Dry fertilizer is hydroscopic, meaning it attracts moisture. It can draw water out of a person's skin and leave it red and sore. These skin burns are usually a minor discomfort, but they can be painful to people with sensitive skin. Dry fertilizer can also get into and irritate the mouth, nose, and eyes. The scalp is another area that is often very sensitive to the effects of dry fertilizer.

Prevent fertilizer burns by keeping the dust away from the skin. Wear a long-sleeved shirt buttoned at the collar and a cap or hat to keep dust out of hair. Change clothes daily or more often if they pick up a lot of dust. Wash face, hands, arms, and other exposed skin several times a day with soap and water. Do not allow the fertilizer to stay in contact with the skin. Wear gloves while in contact with these chemicals.

When handling the materials, let the wind blow dust away. Stand upwind when filling hoppers. Drive crosswind in the field, if possible, so dust is blown off to one side. If dust is a problem, wear goggles to protect the eyes and a filtered respirator to protect the lungs.

Centrifugal broadcast spreaders throw fertilizer particles at high speeds. It can be painful if these particles get into the eyes, ears, or mouth. Stay away from the back of the machine when the spreader is operating.

If spreader blockage occurs, stop the machine and shut off the engine before doing any inspection or maintenance.

Use a safe speed when pulling loaded spreaders because they are heavy. Excessive speed can cause the spreader to veer out of control while going downhill or around corners. These spreaders are not normally equipped with brakes, so only the tractor brakes are available for stopping. Use a safety chain when towing the spreader on the highway. Also, display the SMV (slow moving vehicle) emblem as required by law.

Fertilizer equipment is often cleaned with diesel fuel. The fumes can ignite and burn. Always work outdoors or in a well-ventilated area, and stay away from flames. Do not allow smoking in the area.

Summary

It is difficult to obtain fully uniform application of fertilizer and lime. The most uniform application can be obtained by evaluating the distribution pattern produced by the spreader under normal operating conditions; that is, by using the actual fertilizer in the field in which the material is to be applied and using the proper application rate, gears, and ground speed. The equipment must be properly calibrated and maintained. Operators of the equipment must understand the factors that affect the distribution patterns, the equipment adjustments that will produce the best possible results, and must be willing to spend some time to attain the desired pattern. The result will be maximum returns for the lime and fertilizer dollar. The time spent calibrating and adjusting fertilizer and lime spreaders before they are used each season could easily become the best paying job on the farm.