MANAGING MANURE APPLICATION

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ABSTRACT

Nutrient management plans frequently specify variable manure application rates between fields. Achieving these variable application rates is challenging for on-farm and commercial applicators. Training programs are needed for new applicators and evaluation procedures need to be adopted to monitor actual application rates. On-farm procedures can be used to determine ballpark application rates and to assess appropriate overlapping of spreader loads. New integrated systems are available to provide near real time evaluation of application rates and generation of required records. Adoption of this technology is likely to improve accuracy in manure application rates, improve crop uniformity, improve crop yield, and maintain soil phosphorus at target levels.

INTRODUCTION

Nutrient management plans frequently specify variable manure application rates between fields due to differences in soil phosphorus levels, cropping program, and expected crop yields. Varying application rates provide challenges for both farm management and farm workers. How are these varying application rates communicated to the labor force? Do the manure applicators know how to effectively adjust application rate? How does management assess the accuracy in manure application rate? How does management record manure applications? Resolving these issues are important for meeting the goals of their nutrient management plan.

Training programs for manure applicators are not commonly available in the western US. However, several Midwestern states (IA, IL, MN, WI) have established certification programs for manure applicators. To receive certification, the applicator must attend a workshop and pass a certification exam. A link to the Iowa certification program and their training materials is shown the reference list. Developing a training program for commercial and on-farm applicators in Idaho would likely be a beneficial effort for increasing manure application uniformity and achieving targeted application rates.

This paper is divided into four sections: engineering aspects of manure spreaders, measuring manure application on-farm, evaluation of on-farm methods, and new integrated systems. Understanding these four topic areas is important for controlling manure application on the farm and for training new applicators.

Engineering aspects of manure spreaders

The American Society of Agricultural Engineers has defined procedures for calibrating fertilizer spreaders but these procedures do not transfer well for calibrating manure spreaders. In contrast, European countries have defined procedures (EN 13080) for calibrating and evaluating spreader performance. US researchers use the European techniques for evaluating application uniformity of new spreader designs. Key performance measures include: variation across the spread swath, variation in the direction of travel, and stretch within the tolerance zone. Coefficient of variation (CV) is used to express lateral and longitudinal variation. The stretch within the tolerance zone describes a spreader's ability to maintain a specific rate during the load-out process. It is defined as the percentage of the unloading time during which the manure flow does not deviate more than 10% from a steady flow. Desirable performance includes low CV's for across swath and longitudinal travel variation and a high percentage time with a steady flow characteristic. Performance and uniformity of application has improved due to new equipment designs but is still more variable than dry fertilizer spreaders due the inherent variability in livestock manures on farms.

Application rate and uniformity of manure spreaders are governed by three main factors: manure flow rate, travel speed, and effective application width of the equipment. Operators have a degree of control over all three factors.

Manure flow rate can be adjusted for all spreaders but the procedure is specific depending on design. For many spreaders, flow rate is adjusted by changing the power take-off (PTO) speed, apron speed, or ram speed. Higher speed increases flow rate and slower speed decreases flow rate. Unloading rate may also be changed by increasing or decreasing the discharge opening (hydraulic end gate on a box-type or slinger spreader or the discharge valve on a tank spreader). Changing the pressure inside a tank spreader also affects the rate of unloading.

Adjusting ground speed of the application equipment, while leaving unloading rate constant, is an easy method to adjust application rate. This is also an important reason for the application operator to be diligent about maintaining a constant ground speed for uniform application. Practical speed range can be limited by field roughness; tractor power; excessive residue burial; and time required for disposal.

Swath width characteristics vary depending on spreader type. Conventional rear discharge box spreaders with horizontal augers have a much narrower swath width than side discharge slinger spreaders and rear discharge spreaders with vertical augers. Swath width is controlled by varying end gate opening and varying deflector plate position. Manures tend to have a bell shaped curve distribution behind the spreader's discharge point. Swaths must be overlapped to achieve a more uniform distribution which adds an additional operator control point. For the most uniform application, swaths should be overlapped to the extent that the areas to the side of the spreader receive the same application rate as the area behind the spreader.

Measuring application rate on the farm

Strategies for calibrating manure spreaders have been discussed in numerous Extension publications and farm magazine articles. Examples of current publications with detailed procedures are shown in the reference list. A general discussion of the commonly recommended procedures is provided below.

<u>Tarp Method</u>. For rear discharge spreaders, the maximum manure application rate typically occurs directly behind the manure spreader. The tarp method takes advantage of this fact. To run the test, three to five tarps of known size are placed in the field down range and the applicator drives the spreader over the tarps while applying manure. Tarps are weighed after application and rate is calculated by equation (expressed in tons/acre). If application rate is outside the planned range, a second set of tarps is used and the applicator varies ground speed or

discharge rate from the spreader. Through trial and error, the applicator finds the appropriate speed and discharge rate to achieve desired application rate.

The tarp method has several key advantages: 1) application rate can be tested at any time, 2) the procedure estimates maximum application rate, 3) does not require on-farm scales to measure load weight, and 4) the process is suitable for any size operation. There are a few disadvantages as well including: 1) process is time consuming, 2) does not measure swath width or pattern, 3) must calibrate each spreader, and 4) better calibration results occur when using multiple tarps at each speed setting.

Swath Width and Distance: Area Method. With this method, the applicator spreads a full load of manure in the field. The width of the swath and distance of spread is measured. Application is estimated by dividing the weight of manure spread by area of application. If application rate is outside the planned range, the applicator applies a second load of manure and varies ground speed or discharge rate from the spreader. Through trial and error, the applicator finds the appropriate speed and discharge rate to achieve desired application rate.

The advantages of this method include: 1) application rate can be tested at any time, 2) suitable for any size operation, and 3) easy to perform. Disadvantages include: 1) requires accurate estimate of load weight, 2) requires accurate estimate of spread width and distance, 3) underestimates application rate because it does not include overlap application, and 4) time consuming to measure several loads.

Swath Width and Distance: Tarp Method. The objective of this method is to measure the width of the swath and determine the distance between applications to optimize manure uniformity plus determine application rate from entire load. A series of tarps are laid out in the field and the applicator drives over the center of the tarp pattern. Maximum application rate is determined from the tarps in the center. The side tarps are weighed to determine the point where side application is approximately 50% of the maximum application rate. Optimal interval between swaths (on center) is equal to two times the 50% distance. For example, if the 50% point occurs 7 feet from the center of the application swath, then the next swath should occur 14 feet from the previous swath (distance measured from center of swath).

The advantages of this method include: 1) it detects uneven spread patterns, and 2) determines optimum overlap distance which should increase application uniformity. Disadvantages include: 1) time consuming to measure distance traveled, weigh tarps, and perform calculations, and 2) accurate estimate of load weight required.

Loads per field is the quickest and easiest method for estimating application. The evaluator needs three pieces of information: number of spreader loads applied to field, area of field, and average load weight. Average application rate is calculated by multiplying the number of loads times the average load weight and then dividing by the number of acres. This method has three primary disadvantages. First, application rate in not determined until the job is done. It is too late to adjust the rate if it is above or below target rate. Second, the loads per field method does not measure application variability across the field. In some situations, average application rate will be correct but there is a several fold difference in application rate across the field. Crop yield will vary dramatically across the field with this scenario. Third, loads per field requires a reasonably accurate average load weight.

Evaluation of on-farm methods

Colorado State researchers (Davis and Meyer, 1998) compared the tarp method and the swath and distance method on ten operations. The swath width and distance method resulted in significantly higher measured application rates than the tarp method. When a spreader truck was driven over the tarps, the tarp width was effectively reduced due to being pulled in by the weight of the truck. The data was corrected for this shrinkage, and the tarp method still resulted in lower measured values.

The coefficient of variation (CV) for weights from the three tarps used in the tarp method ranged from 17-56%, with an average CV of 30%. Researchers calculated that three tarps result in 39% probable error, and five tarps result in 30% probable error. In other words, if the goal of the operator was to spread 20 tons manure/acre, three tarps would result in measured values from 12-28 tons/acre, and five tarps would result in measured values of 14-26 tons/acre. The tarp method is useful for "ballparking" application rate and identifying situations where application rates are well above or below target rates.

Spread patterns were evaluated with the swath width method. Seven out of ten spreaders had patterns which were off-center. One of these seven cases could potentially be attributed to strong winds. Another one of the spreaders had one side with 7.5 times the amount of manure on it than the other side. Some of the trucks did not seem to be loaded evenly, but trucks were loaded according to common procedure; therefore, the unevenness of the spreading could be partially attributed to asymmetrical loading and partially attributed to the need for adjustment and improvement of manure spreaders.

Calculated swath widths ranged from 7.5 ft to 16.1 ft, with an average of 11.1 ft. Visual appraisal of manure accumulation on the tarp was as effective in assessing swath width as plotting manure distribution across the swath. Visual appraisal is more appealing for farm use since it is faster and easier to perform than weighing tarps and plotting results.

On average, neither the tarp method nor the swath width and distance method were significantly different from the stated application rate goal of the operator. However, both of the methods were quite variable, making it impossible to calibrate with a fine degree of control. Of course, manure spreading is innately variable, and evaluating a large area from small tarps whether for swath width determination or actual application rate calculation only works if the spreading is uniform.

Integrated Systems

Precision agriculture techniques are being developed and refined for manure application. Manufacturers of liquid and solid manure spreaders are now offering the option of adding scales and indicator devices to their equipment. Load weights are available for each load applied to a field. Application rates while spreading are displayed on the indicator device, allowing the operator to make adjustments and achieve target application goals. Warning lights flash if the application rate is outside the target range for a particular field. GPS units record start and stop locations, enabling manure application rates to be displayed by load across the field. Indicator devices record, time, date, field names, GPS location, and application rate by load. Record keeping is simplified by transferring application data from the indicator device to an on-farm computer with appropriate data management software.

Advanced systems are also available. For an additional price, refined GPS technology is used to show the applicator where to apply each load. This feature improves consistency of overlap between spreader loads. For uptick in price, application data is sent directly from the field to the on-farm computer, greatly simplifying the data transfer process and allowing "real time" monitoring of application. Finally, variable rate technology has been tried with slurry tanks, enabling optimum application and utilization of nutrients from manure.

The new integrated systems are a "value added" practice for custom applicators. Farm operators can easily receive detailed reports for complying with Nutrient Management Plan record requirements. Training of new applicators is enhanced by a real time report on application rates and the applicator can easily see the effects of changing ground speed or other spreader settings on application rate. Improved uniformity of application will lead to more uniform crop growth and yield across the field. Over-application of manure will be less likely, leading to greater compliance with soil phosphorus guidelines.

Precision agriculture techniques work best with consistent manures such as agitated slurries and compost. Other manures can be used but will be more variable in application rate and nutrient composition. Integrated systems provide many benefits for controlling application but are still susceptible to variation due to variable nutrient composition, moisture content, and bedding levels in livestock manures.

Summary

Nutrient management plans frequently call for variable manure application rates between fields. Achieving these variable application rates is challenging for on-farm and commercial applicators. Training programs are needed for new applicators and evaluation procedures need to be adopted to monitor actual application rates. On-farm procedures can be used to determine ballpark application rates and to assess appropriate overlapping of spreader loads. New integrated systems are available to provide near real time evaluation of application rates and generation of required records. Adoption of this technology is likely to improve accuracy in manure application rates, improve crop uniformity, improve crop yield, and maintain soil phosphorus at target levels.

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