CALIBRATION OF MANURE APPLICATION EQUIPMENT ON-FARM

INTRODUCTION

The efficient handing of manure involves taking a number of factors into consideration. Some of these factors are the manure equipment capabilities, rates of application required for specific fields and crops, safety concerns, buffer zones, as well as steps to avoid spills and odour concerns. The objective of this fact sheet is to provide accurate methods to calibrate liquid, semi -solid and solid type manure spreaders on-farm.

An agrologist using the nutrient value of manure and specific field and crop requirements can help the farm operator determine the manure application rate and time of application for each field. To achieve the desired application rate it is necessary to calibrate the manure spreader. Calibration in turn, will determine speed of travel (engine rpm and tractor gear selection) in the field and, for broadcast spreaders, the pattern overlap which determines the swath spacing width. The accurate application of manure results in efficient manure use. This saves money and reduces the risk to the environment from over fertilization, as well as promoting optimal plant growth and improving soil quality.

MANURE SPREADER DISTRIBUTOR TYPES

1. ***Broadcast distributor:*** Since their inception, conventional manure spreaders have used broadcast distributor mechanisms to spread solid and semi-solid manure by horizontal beaters and side discharge. More recently rear vertical beaters have also been used. A plate type distributor, located high on the rear of the spreader, has traditionally been used to spread liquid manure through a large nozzle (orifice). Recently manufacturers have developed a lower rear mounted, inverted design, single nozzle manure distributor. Its nozzle is approximately two meters closer to the soil surface, resulting in reduced off-target manure drifting.

2. Low profile spreading distributors: Newer technology for the spreading of liquid manure has been adopted over the last several years, especially for row crops. These systems include placement by injection, thus reducing odour dispersion and nutrient losses. Rear mounted boom spreaders have smaller nozzles (spaced at a meter apart, as shown in Fig. 1) or multiple drop tube distributors as shown in Fig. 2. Foreign matter in the manure can cause plugging in these low profile distribution systems but, if maintained and used properly, they are more accurate than broadcast types and help reduce the drifting of small odour carrying particles from the field.

Figure 1. Rear mounted boom spreader

UNIFORM MANURE APPLICATION

Uniform application of manure on agricultural lands, at the appropriate rate, may provide the necessary nutrients for a specific crop. Excess manure application due either to non-uniform spreading or higher than appropriate rates will result in nutrients being lost to the environment. The application of manure, as accurately as possible, involves several important machinery considerations.

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Figure 2. Drop tube distribution system and resulting manure application to soil surface

1. ***Speed in the field:*** It is essential to keep the spreader at a constant speed in the field while applying manure. A change in speed of 30% going up or down the slope will increase or decrease the application rate by the same 30%. Constant speed is controlled by the tractor throttle to maintain engine rpm.

2. ***Equipment setup:*** The second set of considerations relates to spreader components: their inspection, maintenance and setup. When a farm operator adjusts the level of a single nozzle distributor, it results in a more uniform spread pattern on both sides of the spreader. It is also important that the mechanism that distributes the manure uniformly onto the field, and devices such as pipes, augers, flails and pumps that deliver the manure to the distributor are in excellent working condition, not bent, damaged, worn or defective. Rocks and foreign matter that become incorporated in the manure often damage the augers, beaters, flails or distributor mechanism of semi-solid or solid manure spreaders. Keeping components in good working condition is a challenge that requires frequent inspection, maintenance and replacement of parts as specified in the operator's manual.

   It is worth periodically checking the time it takes to spread a full load. For liquid spreaders in particular, this time is usually the same. A variation in spread time would indicate a problem with the spreader distributor becoming restricted and/or a faulty delivery mechanism such as a pump, gravity feed supply tank, trash chopper, and conveyor chain or augers on box spreaders.

3. ***Overlap of spread patterns:*** With broadcast spreaders, overlapping of manure is necessary in order to obtain the desired application rates and uniform distribution across the entire field. In most cases, operators use visual observation of the adjacent spreader wheel tracks to achieve parallel swath widths in the field. The **swath spacing width** is the distance from the center of one pass to the center of the next spreader pass. The swath spacing width required for broadcast spreaders is less than the maximum spread pattern. Overlapping of 100% is normally required to achieve uniform coverage for liquid manure broadcast spreaders. To explain further, if the spread pattern of a broadcast spreader with a low profile single nozzle distributor was 10 meters wide, then a 100 % overlap would result in a 5 meter swath spacing width. The boom type distributor, with several nozzles on a boom, requires only a slight overlap of 0.5 m between the adjacent patterns to achieve uniformity.

4. ***GPS technology:*** GPS instrumentation can improve the accuracy of manure applications. It is important that the farm operator understands the GPS components and how they operate in order to keep them working properly. GPS technology can be used to obtain parallel swaths that are accurately spaced across the entire field. GPS location accuracy depends on the differential correction system that is available. It is very important to accurately calibrate the GPS unit for each farm power unit such as a self-propelled sprayer, field truck, or tractor with implement. In turn the GPS will more accurately calculate field area and application rate. The GPS memory will also record and re-locate the center line of the spreader passes in the field and record complete application work for that date and field.

DETERMINING THE CAPACITY OF MANURE SPREADERS

Accurate calibrations require knowledge of the capacity, volume or weight, of a full load of manure. These capacities will be used later in the calibration calculation formula. It is essential to fill every spreader load to that capacity for consistent calibration results. Liquid spreaders usually have known capacities or the volumes can be easily calculated.

Solid or semi-solid spreaders have manufacturer published volume capacities. Stuck (level) capacities are easier to calculate than heaped capacities. Heavy duty vehicle scales are almost a must to obtain an accurate weight. Where such scales are not available the alternative method to determine weight will be to measure the manure weight per volume (density). The density of solid manure is quite variable and depends on the amount of moisture and type of bedding used. To determine the density, it is best to weigh at least five 20 liter buckets of manure and then calculate the average weight. Weigh the pail empty and then full of manure, having packed the manure evenly in the pail each time. A step on balance works fine for this process.

Manure density = weight (kg) ÷ pail volume (liters)
= 12 kg divided by 20 liter (pail)
= 0.6 kg/liter

The calculation of the actual spreader capacity (value **A** in Table 1) for a spreader rated at 5 cubic meters is then done as follows:

Spreader capacity = manufacturer's volume capacity
x volume conversion factor
x manure density

$= 5\ m^3 \times 1000\ liters/m^3 \times 0.6\ kg/liter$
= 3000 kg
= 3 metric tonnes

CALIBRATION METHODS

There are three main methods used in the calibration of manure spreaders. The "swath spacing width and distance" is the most commonly used method. The "plastic sheet" method can help establish the required overlap for uniform coverage and establishes the swath spacing width. The last method, "loads per field", is used to verify the results from the first two methods.

1. Swath spacing width and distance method: This method requires measurement of the distance traveled in the field to empty a full spreader load. Distance can be measured using a land wheel or long tape measure. Some calibration methods use wheel revolutions of the tractor, but if slippage of the rear drive wheel is not taken into account the distance will be exaggerated by up to 15%. Therefore measure the actual distance traveled in the field to account for slippage of drive wheels. The second measurement required is the swath spacing width, as explained earlier in the section that discussed overlap. The last value required is the actual spreader capacity. To complete the desired calculation, refer to the formula under Table 1.

Hammond et al. (1994) developed an excellent article that evaluates the spread patterns of solid and semi-solid manure spreaders. Hammond's method will also determine the required overlap and swath spacing width more accurately than using visual observation.

2. The plastic sheet method: Use small wooden stakes to place a plastic sheet(s) or plastic tarp(s) on the field at the width of a full spread pattern (Fig. 3.). Sheets with the dimensions of 3 x 3 meter are easy to manage when calculating weights. The spreader shown in Fig. 4 is a side discharge unit. When spreading with a box rear discharge unit, spread manure over the middle of the sheet(s). Overlap spreading will be required on both sides of the initial spreader pass to achieve uniform spreading results Then obtain the weight of the manure, minus the sheet(s), using a hanging or platform scale. Research has shown up to 30 percent variation using this method, so repetition is critical to accurately determine an average application rate. Repeat this weight calculation 4 or 5 times.

Figure 3. The plastic sheet method

The calculation of the application rate using a 3 x 3 meter sheet that has collected 25 kg of manure, is done as follows:

Application rate = (manure weight ÷ sheet area)
x conversion factor (value **D** from Table 1)
$= (25\ kg \div 9\ m^2) \times 10{,}000\ m^2/ha.$
= 27,778 kg/ha
= 27.8 metric tonnes/ha.

3. Loads per field method: Record the number of loads of manure applied to the whole field and divide by the area of the field. This is also an excellent method to verify the calculations for the swath and distance method while providing good information for nutrient management records.

ADJUSTMENTS TO THE APPLICATION

RATE

Once the initial calibration calculation is complete, adjustments may be required. If the actual spreader application rate is lower or higher than the desired rate, then it may be altered using a combination of the following suggestions:

1. Change field driving speed: Reducing speed will increase the application rate proportionately.

2. Change swath width: Reducing swath spacing width increases the rate proportionally.

3. Change bed conveyor speed**:** For semi-solid or solid manure spreaders change the speed of the bed conveyor chain or change gate openings for side discharge spreaders

Make the change and then repeat the calibration calculation to confirm results.

Figure 4. Side discharge manure spreader

REFERENCES

Hammond, C., C. Gould and W. Adkins. University of Georgia. 1994. **Calibration of Manure Spreader Including Swath Width**.

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Hilborn, D. 1992. Agdex 538/743. **Land Application of Liquid Manure in an Environmentally Responsible Manner**.

For further information on the calibration of manure or fertilizer application equipment, please contact your local agrologist, crop consultant or Agri-Environmental Club Coordinator.

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Manure Application Equipment Calibration Worksheet

Step One: Determine the Capacity (**A**) of the manure spreader, which could be in any of the following units: litres (L); kilogram (kg); metric tonnes (mt); US gallons (USG); imperial gallons (Imp.G); pounds (lbs) or tons. Fact sheets are available that calculate spreader tank volumes. To determine weight of solid or semi-solid manure refer to density calculations which are explained below. Liquid hog manure density is assumed to be 1.0 kg per liter or 62.4 lbs per ft^3. Dairy manure density should be calculated.

Capacity (**A**) = manufacturer's volume capacity x volume conversion factor x manure density

Step Two: Determine the Swath Width (**B**) in meters (m) or feet (ft). It is very important to carefully read and understand the section on swath width in this fact sheet.

Step Three: Determine the distance (**C**) traveled to spread one full load of the manure spreader in meters (m) or feet (ft) using a land wheel or tape measure. When calculating distance by tractor rear wheel circumference times the number of revolutions, check tractor wheel circumference in the field to account for rear wheel slippage.

Step Four: Enter these input values (**A, B and C**) in the formula below table 1 to calculate the Manure Application Rate (**MAR**). Use the units indicated from any <u>one</u> row of the table as well as the corresponding conversion factor (**D**). This application rate can then be used in the various nitrogen management worksheets developed by the *Greenhouse Gas (GHG) Taking Charge Team.*

Table 1: Input units for the manure application rate formula.

Manure Application Rate (MAR)	Spreader Capacity (A)	Swath Width (B)	Spreader Distance (C)	Conversion Factor (D)
litres per ha	Litres	meters	meters	10,000 m2/ha
kg per ha	Kg	meters	meters	10,000 m2/ha
metric tonnes per ha	metric tonnes	meters	meters	10,000 m2/ha
US gallons per acre	US gallons	feet	feet	43,560 ft2/acre
imp.gallons per acre	imp. Gallons	feet	feet	43,560 ft2/acre
pounds per acre	lbs.	feet	feet	43,560 ft2/acre
tons per acre	tons (2000 lb)	feet	feet	43,560 ft2/acre

Manure Application Rate (**MAR**) uses inputs from any one line of Table 1 above.

MAR = ______ (A) ÷ _______ (B) ÷ ________ (C) x ________(D) = __________

Ex: To determine the manure application rate in metric tonnes per ha, choose the inputs from the third row in Table 1. If the spreader has a Capacity (A) = 3.5 tonnes, Swath Spacing width (B) = 6 meters, Spreader distance (C) = 340 meters, then input the conversion factor (D) = 10,000.

result : **MAR** (metric tonnes/ha) = 3.5 ÷ 6 ÷ 340 x 10,000 = 17.2 metric tonnes/ha

Table 2: Conversion factors for volume and area units

Volume	1.0 m^3 = 1000 Litres (L)	1.0 m tonne = 1000 kg	1.0 m^3 =1.0 metric tonne (liquid)
Volume	1.0 yd^3 = 0.76 m^3	1.0 bushel = 36 Litres (L)	1.0 bushel = 1.26 ft^3
Volume	1.0 kg = 2.2 lbs	1.0 Imp.G = 1.2 US Gallon	1.0 Imp.G = 4.55 Litres (L)
Area	1.0 ha = 10,000 m^2	1.0 acre = 43,560 ft^2	1.0 ha = 2.47 acres

NOTE: The conversion of values from one system of units to another requires multiplication or division. What is done to one side of the equal sign is done to the other side.

Ex: 5 x 1.0 ha = 5 x 2.47 acres, so: 5 ha = 12.35 acres

Divide both sides to reverse a conversion.

Ex: 1.0 ha ÷ 2.47 = 2.47 acre ÷ 2.47, so: 0.405 ha = 1.0 acre