

# Calculating Target Manure Application Rates for Solid and Semi Solid Manure Spreading

## CONSIDERATIONS WHEN APPLYING SOLID/SEMI SOLID MANURE

Making the effort to properly value our manure will help with finances and fertility as well as mitigating environmental impacts. Since the advancement of synthetic fertilizer, it has been common to undervalue the nutrients in manure. Additionally, the use of manure can be complex as there is uncertainty about the exact nutrient content and the volume of manure applied. A common method for adding manure to a nutrient management plan (NMP) is to simply subtract the estimated nutrients in manure and apply a little extra fertilizer to be sure the crop has enough. So, applying manure isn't always a simple practice. This factsheet focuses on the application rate side of the NMP equation, while pointing to other information sources for determining nutrient concentrations in manure.

We can approach manure values either proactively or reactively. In both cases, we require an accurate estimate of the nutrient concentration in the manure. These can come either from book values or by taking manure samples and sending them to the lab. The proactive approach is to decide the rate of manure needed to apply to meet crop nutrient requirements, and then to calibrate the spreader to apply that amount. The reactive approach is to spread manure on the field, then estimate the rate applied and then use this value to adjust your fertilizer application. Either approach will work, although the proactive approach will result in less risk of overapplication of nutrients that could lead to environmental impacts, more efficient use of on-farm nutrients, less risk of lodging and possibly more money at the end of the year.

Calculating your manure application rate includes multiple factors; the weight of your equipment, the weight of the manure, your application area for each, the nutrient concentration in your manure and the target application rate for your manure. Knowing these factors will assist in accurate application rates to minimize losses.

## PLANNING MANURE APPLICATIONS: BEFORE YOU BEGIN

A sound manure application plan requires:

- Setting realistic nutrient application targets based on regular soil tests (typically within the last three years) and accounting for other nutrient sources and field history, such as past applications, past crop yields and crop nutrient removal and legumes in rotation.
- Knowing the concentration of available nutrients in your manure, either from lab analyses or book values.
- Adjusting equipment for a uniform spread pattern and accounting for overlap between passes.
- Applying your manure at the appropriate time to get the most out of your nutrients for the season.

### Resources for determining the nutrient concentration in manure:

For sampling directions, refer to Perennia's factsheet, [How to take a Compost and a Solid Manure Sample](#).

To calculate the nutrients in your manure from a lab analysis, refer to Perennia's factsheet, [How to Interpret a Manure Analysis Report](#).

For recent book value of the nutrient values of livestock manure, refer to OMAFA's factsheet, [Available Nutrients and Value for Manure From Various Livestock Types](#).

Another reminder before you dive into manure application rates for your crop are checking your most recent soil analysis. Especially if you have been applying manure to meet the nitrogen requirements of your crop for consecutive years. This could lead to buildup of both phosphorus (P) and potassium (K) in your soil, as manure generally has more of these nutrients than nitrogen relative to what the crop removes. High P could be an environmental concern, as runoff causes algae blooms in freshwater, while elevated K may affect the forage quality for dry cows, leading to greater risk of milk fever.

## CALCULATIONS FOR APPLYING TARGET RATES OF MANURE

The three key pieces of information for applying a target rate of manure are:

1. The weight of manure on each spreader load
2. The target rate of manure application (weight/area)
3. The time or speed in which you need to run to apply a load.

From these three pieces of data, the area that each load needs to cover can be calculated and then the speed the tractor needs to travel to apply the proper rate.

**Note:** the calculations have been provided in metric units because the math is much simpler.



### Step 1: Determine manure weight per load

1. Integrated scales (load cells) on the spreader. This is simplest, since the weight of each load can be shown directly on the scale readout. Be sure to follow manufacturer's instructions for period calibration of the load cells with known weights.
2. External scales. Weigh the tractor and spreader together when empty, then repeat when fully loaded. If pad-scales (or wheel load scales), then best practice is to weigh just the spreader to minimize error in weight from the hitch. Ideally, weigh five representative loads to determine an average net loaded weight (Full Weight - Empty Weight = Manure Weight).

**Example manure load** = 10,000 kg (full weight) – 4,500 kg (empty weight) = 5,500 kg (manure weight)

3. Estimate the weight of a load from the volume of the spreader and the density of the manure. The volume of the spreader could be based on the manufacturer's rated capacity or the measured length times the width times the depth. The manufacturer's volume will often be listed in bushels or cubic feet in the United States or in cubic metres in Metric. If the capacity is in bushels, assume 1 bushel = 0.35 cubic metres or 1.25 cubic feet. The weight of a spreader load will be the volume times the density of the manure.

Both volume and density will be most accurate for semi-solid manure which can generally only fill the spreader level full and has a density close to that of water (1 kg/litre, or 1 metric tonne/cubic metre). The density of solid manure will be much more variable depending on the amount of bedding and moisture, plus it can be piled higher than the sides of the spreader. It should be measured by weighing an empty 20 litre pail, then filling it level full with manure and weighing it again. Deducting the weight of the pail will give the net weight of 20 litres of manure, and multiplying this figure by 50 will give the weight of a cubic metre. The volume of a spreader load will be the width of the box in metres times the length times the height. For semi-solid manure the height will be to the top of the box (or whatever depth you fill the spreader), while for solid manure the height will be the depth of the box plus half the height of the pile above the box (assuming a roughly triangular profile).

### Metric Example:

**Manure density** = 10 kg net weight for 20 litres x 50 = 500 kg/cubic metre

**Spreader volume** = 2 m width x 4 m length x 1.2 m height (1 m box depth + ½ of 0.4 m stacked above box) = 9.6 cubic metres

**Manure weight** = 9.6 cubic metres x 500 kg/cubic metre = 4,800 kg per load (to be used in Step 2)

### Imperial Example:

**Manure Density** = 30 lb net weight for a 20 litre pail (converts to a volume of 20 litres divided by 28.32 litres/cubic foot = 0.7 cubic feet) = 30 lb / 0.7 cubic feet = 43 lb/cubic foot

**Spreader Volume** = Rated capacity from manufacturer of 250 bushels x 1.25 cubic feet/bushel = 313 cubic feet

**Manure weight** = 43 lb/cubic foot x 313 cubic feet = 13,459 lb = 6.73 tons per load

## Step 2: Determine area for each load

The area that each load must cover is simply the weight of manure in each load divided by target application rate. *The target rate has been calculated elsewhere from the available nutrient content in the manure and the nutrient requirements of the crop.* At this stage, be sure that the units for the manure weight in the spreader and the target rate are the same. Fortunately, it is easy to convert T/ha to kg/ha by multiplying by 1,000.

**Example:** The crop requires 50 kg of available N/ha from manure. Based on the estimated available N content of the manure, the calculated manure application rate is 20 T/ha

**Example target rate** = 20 T/ha x 1,000 = 20,000 kg/ha

**Example manure weight** = 4,800 kg/load (see Step 1)

**Example area per load** = 4,800 kg/load / 20,000 kg/ha = 0.24 ha/load

## Step 3: Determine travel distance for each load

The distance you travel to unload is calculated as the area per load divided by the spread width, which will be quite variable depending on the type of spreader you have. The horizontal beater spreader might have a total width of twice the width of the spreader, while the high-capacity vertical beater spreaders might have a spread width of 20 metres or more. Be sure to include any overlap in determining your spread width. The distance that counts is from the centerline of one pass to the centerline of the next.

To determine the travel distance, you should convert the area per load from hectares to square metres by multiplying by 10,000.

**Example area per load** = 0.24 ha x 10,000 square metres/ha = 2,400 square metres

**Example spread width** = 4 metres

**Example travel distance** = 2,400 square metres / 4 metres = 600 metres



## Step 4: Determine travel speed

Once you know the travel distance, the other key piece of information is how long it takes to unload the spreader once you get to the field. With this, you can calculate the speed you will need to drive to apply the target rate of manure. The unloading rate is usually variable for your spreader with mechanical, hydraulic or electrical controls, so it may take a few tries to find an unloading rate that provides a reasonable travel speed at the target rates you hope to achieve.

**Example unloading time** = 4 minutes = 240 seconds

**Example travel distance** = 600 metres

**Example travel speed** = 600 metres / 240 seconds = 2.5 m/sec x 3.6 = 9 km/hr

The conversion factor of 3.6 is from m/sec x 3,600 sec/hr / 1,000 m/km = km/hr.

A travel speed of 9 km/hr (about 5.5 mph) is achievable on smooth fields but it is much faster than many spreaders travel when unloading. In the past, there were many cases where manure applications that were credited for a 20 tonne/ha rate were actually receiving double that rate or more.

## CALCULATIONS FOR CHECKING MANURE APPLICATION RATES

### Method 1: Measured area covered by each load

These calculations are largely the same as for calibrating application rates, but the outcome is the rate applied rather than the travel speed to meet a target rate. It involves weighing the actual amount of manure spread over a known area.

1. Determine manure weight per load. These calculations are the same as in Step 1 above.
2. Measure application area. Measure the length and width of the ground covered by the manure in one load. Avoid measuring the very beginning or end of the pattern where the spreader may not be at full capacity. This can easily be done with GPS or if needed a regular measuring tape for the width and an acreage measuring wheel for the length.

**Example area** = (25 metres (width) \* 310 metres (length)) / 10,000 (m<sup>2</sup>/hectare) = 0.775 hectares

Calculate the rate by dividing the manure weight per load by the application area.

**Example manure load** = 10,000 Kg (full weight) – 4,500 (empty weight) = 5,500 Kg (manure weight)

**Example area** = (25 metres (width) x 310 metres (length)) / 10,000 (m<sup>2</sup>/hectare) = 0.775 hectares

**Example manure application rate** = 5,500 kg / 0.775 ha = 7,097 kg/ha / 1,000 kg/T = 7.1 T/ha

### Method 2: Measuring manure applied to small areas with tarps

If scales are not available, you can estimate the application rate by collecting manure on tarps

1. Prepare tarps. Use three tarps of a known size (e.g., 2 m x 2 m, or 56" x 56"). Pro Tip: A 56-inch x 56-inch tarp equals 1/2,000 of an acre; for this specific size, 1 pound of collected manure equals 1 ton per acre applied to the field.
2. Weigh empty equipment. Weigh a 20 litre bucket and one clean tarp on a platform scale and record the weight.
3. Apply manure. Stake the three tarps in the field at the beginning, middle and end of the spreading pathway. Drive over them at your normal operating speed.
4. Collect and weigh. Carefully place each tarp with the manure into the bucket and reweigh. Subtract the empty bucket/tarp weight to find the manure weight for each.
5. Average the results. Average the weight from the three tarps. If using a 56" x 56" tarp, this average weight in pounds is your application rate in tons per acre. For other sizes, use a calibration chart or calculate based on the tarp's square footage.

### Method 3: Counting loads to cover a field

This method uses the weight of manure in each load of the spreader and the total field size to determine the rate.

Determine load weight using the calculations in Step 1 above.

1. Track applications. Count the total number of loads applied to the field and multiply by the weight per load to determine the total weight applied to the field. Divide the total weight applied to a field by the field's acreage to find the average tonnes per hectare or tons per acre.

#### Imperial Units Example of Method 3:

**Scenario:** A producer uses a spreader with a listed capacity of 250 bushels to cover a 10-acre field. It takes 40 loads to finish the field.

**Determined load weight** = 6.73 tons

**Total weight for field** = 40 loads x 6.73 tons = 269.2 tons

**Rate** = 269.2 tons/10 acres = 27 tons/acre

#### Metric Units Example of Method 3:

**Scenario:** A producer uses a spreader with a capacity of 9.6 cubic metres to cover a 6-hectare field. It takes 30 loads to finish the field.

**Determined load weight** = 4800 kg, or 4.8 metric tonnes

**Total weight for field** = 30 loads x 4.8 tonnes = 144 tonnes

**Rate** = 144 tonnes/6 hectares = 24 tonnes/hectare

In the Imperial example, a 250-bushel spreader applying 40 loads to 10 acres results in a rate of 27 tons/acre. In the Metric example, a spreader applying 30 loads to 6 hectares results in a rate of 24 tonnes/hectare



## TECHNOLOGY FOR MANURE APPLICATIONS

The newest spreading equipment comes with many options to make the accurate application of manure easier and more precise. In addition to load cells that measure the weight of manure in each load, some spreaders have integrated these with rate controllers that automatically spread the desired rate across the field. The simplest ones match the feed rate to the speed of the tractor, so you can set your desired rate per acre and it will apply it. More complex systems will integrate with GPS to use a prescription application map, allowing variable rates of manure across the field and automatically shutting off if you are driving over an area that has already been manured or into a buffer zone where manure application is restricted. As with any technology, regular maintenance and calibration is necessary to keep the equipment operating as it should.

There are also many software packages available to help with the calculations for calibration, application travel speeds and application rates, along with the available nutrient contents of the applied manure. One of these is the AgriSuite software package, which was developed by the Ontario Ministry of Agri Food and Agriculture. These tools can help simplify the process of applying appropriate amounts of manure for crop productivity and environmental protection.

## SUMMARY

- Consistency is key: Use the same tractor gear and engine speed when checking application rates that you plan to use in the field.
- Check accuracy: If your desired application rate doesn't match your calculated results, adjust your travel speed or equipment settings and re-test.
- Keep records: Maintain detailed logs of the rate, method and date of all applications for future planning.

## REFERENCES

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## APPROXIMATE CONVERSION FACTORS

### Weight

1 kg = 2.2 lb

1 metric tonne = 1.1 imperial ton

1 ton/ac = 2.24 metric tonne/ha

### Volume

1 US bushel = 1.25 cubic feet

1 US bushel = 0.35 cubic metres

1 cubic metre = 35 cubic feet

1 cubic foot = 28.32 litres

1 cubic metre/ha = 14.3 cubic feet/ac

### Density

1 lb/cubic foot = 16 kg/cubic metre

1 lb/US bushel = 12.8 kg/cubic metre

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