

Calculating Dairy Manure Nutrient Application Rates

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T. Downing

Whether your goal is to manage manure application to balance for nitrogen (N) or phosphorus (P), knowing how much nutrient you are applying to your fields is a crucial step toward ideal manure management. Determining the relationship between the volume of manure and the amount of nutrients applied is essential.

This publication describes how to calculate nutrient application rates and calibrate waste-handling equipment. It covers typical equipment found on dairies. Nitrogen is used in the examples, but the same techniques can be used for phosphorus.

Generally, it is desirable to apply no more than 100 pounds of nitrogen per acre at a time. See the publications listed under “For more information” (page 5) to learn how to determine appropriate nutrient application rates for your crop and location.

Doing the calculations

To calculate nutrient application rates, you need to know three things:

- The concentration of nutrients in the manure
- How much manure (pounds or gallons) you have applied
- The area (square feet or acres) that received the application

Calculating rates with a stationary gun

1. Measure the amount of manure applied

Place several straight-sided, flat-bottom buckets in the area where the gun is to apply liquid. Run the gun for a predetermined amount of time (for example, 30

minutes) and then turn off the pump. Pour the contents of all the buckets into one bucket and measure the depth of the liquid. Divide the depth by the number of buckets. The result is the inches of liquid manure applied in 30 minutes. For example, let's say you applied ½ inch in 30 minutes.

2. Measure the area covered

To calculate the area of a circle, multiply the radius squared by 3.14. (The radius is half the diameter.) For example, if your stationary gun covers a circle that is 180 feet across, then the radius is 90 feet. Multiply 90 feet by 90 feet by 3.14 to get the total area in square feet (25,434 square feet). There are 43,560 square feet in an acre, so 25,434 square feet is approximately 0.58 acres:

$$\frac{25,434 \text{ ft}^2}{43,560 \text{ ft}^2/\text{acre}} = 0.58 \text{ acre}$$

3. Convert the inches applied to gallons

If you had an average of ½ inch of liquid manure in your buckets, you can assume you applied ½ inch over the 25,434 square feet.

- a. First, convert the square feet to cubic feet by dividing 25,434 by 24 (½ inch in the bucket is 1/24 of a foot). This is equivalent to 1,059 cubic feet of liquid manure.

$$\frac{25,434 \text{ ft}^2}{24} = 1,059 \text{ ft}^3$$

- b. Now, convert the cubic feet to gallons. There are 7.5 gallons per cubic foot, so multiply 1,059 cubic feet by 7.5. The result is 7,942 gallons pumped in 30 minutes.

$$1,059 \text{ ft}^3 \times 7.5 \text{ gal/ft}^3 = 7,942 \text{ gal}$$

4. Calculate the total amount of nitrogen applied

If the nitrogen concentration of the manure is 10 pounds per 1,000 gallons, and you applied 7,942 gallons, then you applied 79 pounds of nitrogen.

$$\frac{7,942 \text{ gal} \times 10 \text{ lb N}}{1,000 \text{ gal}} = 79 \text{ lb N}$$

5. Calculate the amount of nitrogen applied per acre

Since you covered 0.58 acres, you applied the equivalent of 136 pounds of nitrogen per acre.

$$\frac{79 \text{ lb N}}{0.58 \text{ acres}} = 136 \text{ lb/acre}$$

Calculating rates with a traveling gun

Calibrating a traveling gun, or traveler, involves the same principles described for a stationary gun, but you adjust for the speed of the traveler (Figure 1).

For a traveler, you need to know the width of application, the number of feet of hose pulled out (the distance covered by a single pass), and the speed at which the gun is moving. For example, let's say your application is 240 feet wide and each pass is 1,000 feet long (for a total area of 240,000 square feet), and that the traveler moves at 6 feet per minute.

1. Measure the amount of liquid applied

During the application, place several straight-sided, flat-bottom buckets throughout the pass area. After one pass, combine the liquid waste collected in all the buckets into one bucket and measure the depth of the liquid. Divide this amount by the number of buckets. The result is the inches of liquid manure applied in one pass. For example, let's say your application averaged $\frac{1}{3}$ inch.

2. Convert the inches applied to gallons

- First, convert the square inches to cubic feet by dividing 240,000 by 36 ($\frac{1}{3}$ inch in the bucket is $\frac{1}{36}$ of a foot). This is equivalent to 6,667 cubic feet of manure.

$$\frac{240,000 \text{ ft}^2}{36} = 6,667 \text{ ft}^3$$

- Now, convert the cubic feet to gallons. There are 7.5 gallons in a cubic foot, so multiply 6,667 cubic feet by 7.5. The result is 50,002 gallons.

$$6,667 \text{ ft}^3 \times 7.5 \text{ gal/ft}^3 = 50,002 \text{ gal}$$



Figure 1. Calibrating a traveler involves the same principles described for a stationary gun, but you adjust for the speed of the traveler.

3. Calculate the total amount of nitrogen applied

If the manure contains 8 pounds of nitrogen per 1,000 gallons, and you applied 50,002 gallons, then you applied 400 pounds of nitrogen.

$$\frac{50,002 \text{ gal} \times 8 \text{ lb N}}{1,000 \text{ gal}} = 400 \text{ lb N}$$

4. Calculate the amount of nitrogen applied per acre

Four hundred pounds of nitrogen applied over 5.5 acres (roughly 240,000 square feet) equals around 73 pounds of nitrogen per acre.

$$\frac{400 \text{ lb N}}{5.5 \text{ acres}} = 73 \text{ lb N/acre}$$

5. Calculate application rates at various speeds

From these calculations, you can generate a table that easily demonstrates the amount of nitrogen applied at various speeds (Table 1). In the example above, the speed of the traveler was 6 feet per minute. At 3 feet per minute, the application rate would be twice that at 6 feet, or 146 pounds of nitrogen per acre.

Calculating rates with a liquid wagon or drag-hose

The following are two ways to calibrate liquid wagons to determine nutrient application rates.

The most common method

Determine the total volume of liquid applied to a field and then calculate the nutrients applied.

Table 1. Example calibration chart						
Traveler speed (feet/minute)	Inches applied	N applied per acre (lb) (if 8 lb N/1,000 gal)	Total N applied (lb)			
			500 ft hose pulled	1,000 ft hose pulled	1,500 ft hose pulled	
2.0	1	219	600	1,200	1,800	
3.0	0.66	146	400	800	1,200	
4.0	0.5	109	300	600	900	
6.0	0.33	73	200	400	600	

Fill in your own farm's numbers here						
Traveler speed (feet/minute)	Inches applied	N applied per acre (lb) (if 8 lb N/1,000 gal)	Total N applied (lb)			
			500 ft hose pulled	1,000 ft hose pulled	1,500 ft hose pulled	
2.0						
3.0						
4.0						
6.0						

1. Measure the amount of liquid applied

If you hauled 30 loads of liquid with a wagon that holds 3,000 gallons, you hauled 90,000 gallons of liquid.

$$30 \text{ loads} \times 3,000 \text{ gal} = 90,000 \text{ gal}$$

It is important to realize that although most liquid wagons are rated for a specific volume, the actual working volume is less. For example, a 3,000-gallon wagon might deliver only 2,700 gallons to the field.

2. Calculate the per-acre manure application rate

If the manure is applied to a 10-acre field, this is equivalent to 9,000 gallons per acre.

$$\frac{90,000 \text{ gal}}{10 \text{ acres}} = 9,000 \text{ gal/acre}$$

3. Calculate the per-acre nitrogen application rate

If the manure has a nitrogen concentration of 10 pounds of nitrogen per 1,000 gallons, you applied 90 pounds of nitrogen per acre.

$$\frac{9,000 \text{ gal} \times 10 \text{ lb N}}{1,000 \text{ gal}} = 90 \text{ lb N}$$

A second method

This method measures the volume of liquid applied to a small area and uses that quantity to calculate the volume applied over the entire field. It assumes that the application rate is constant.

1. Measure the amount of liquid applied

Place several trays, pans, or short buckets in the field to catch liquid applied with one pass (Figure 2). Pour the contents of all the pans into one pan and measure the depth of the liquid. Divide this number by the number of pans. The result is the inches of liquid manure applied in one pass. For example, let's say your application averaged $\frac{1}{2}$ inch.

2. Convert the inches applied to gallons applied per acre

- First, convert the inches to cubic feet per acre by dividing 43,560 (the number of square feet in an acre) by 24 ($\frac{1}{2}$ inch in the bucket is $\frac{1}{24}$ of a foot). This is equivalent to 1,815 cubic feet of liquid manure per acre.

$$\frac{43,560 \text{ ft}^2}{24} = 1,815 \text{ ft}^3/\text{acre}$$



Figure 2. Place several trays, pans, or short buckets in the field to catch liquid applied with one pass with both the drag-hose application or the tank wagon.

- b. Now, convert the cubic feet per acre to gallons per acre. There are 7.5 gallons per cubic foot, so multiply 1,815 cubic feet by 7.5. The result is 13,612 gallons per acre.

$$1,815 \text{ ft}^3/\text{acre} \times 7.5 \text{ gal}/\text{ft}^3 = 13,612 \text{ gal}/\text{acre}$$

3. Calculate the nitrogen application rate

If the concentration of nitrogen is 10 pounds per 1,000 gallons, the rate of nitrogen applied is 136 pounds per acre.

$$\frac{13,612 \text{ gal}/\text{acre} \times 10 \text{ lb N}}{1,000 \text{ gal}} = 136 \text{ lb N}/\text{acre}$$

Calculating rates with a solids spreader

The following are two ways to calibrate solids spreaders.

The most common method

Calculate the nutrient (e.g., nitrogen) content of each spreader load and multiply that number by loads per acre or loads per field.

1. Calculate the capacity (in cubic feet) of your spreader

If your spreader is 16 feet long, 5 feet wide, and 5 feet deep, it holds 400 cubic feet per load.

$$16 \text{ ft} \times 5 \text{ ft} \times 5 \text{ ft} = 400 \text{ ft}^3$$

2. Calculate the nitrogen application rate

If your solid manure has a concentration of 10 pounds of nitrogen per 100 cubic feet, you are applying 40 pounds of nitrogen per load of solids.

$$\frac{400 \text{ ft}^3 \times 10 \text{ lb N}}{100 \text{ ft}^3} = 40 \text{ lb N}$$

3. Calculate the amount of nitrogen applied to the field

Record the number of loads hauled on each field. Multiply the number of loads by the amount of nitrogen per load. For example, if you hauled 25 loads of solids, multiply 25 loads by 40 pounds of nitrogen per load for a total application of 1,000 pounds of nitrogen.

$$25 \text{ loads} \times 40 \text{ lb N}/\text{load} = 1,000 \text{ lb N}$$

4. Calculate the number of pounds of nitrogen applied per acre

Divide the total amount of nitrogen applied by the number of acres, in this example 10 acres.

$$\frac{1,000 \text{ lb total N}}{10 \text{ acres}} = 100 \text{ lb N}/\text{acre}$$

A second method

This method measures the pounds of solids applied to a small area and uses that quantity to calculate the volume applied over the entire field. It assumes that the application rate is constant.

1. Measure the amount of solids applied

Place a tarp or piece of plastic in the field and apply solids over the area (Figure 3). A 10-foot by 10-foot tarp measures 100 square feet. There are 43,560 square feet in an acre, so 100 square feet is $\frac{1}{435}$ of an acre.

$$\frac{100 \text{ ft}^2}{43,560 \text{ ft}^2/\text{acre}} = \frac{1}{435} \text{ acre}$$

After spreading across the sample area, fold the tarp and weigh the solids collected on it. For example, let's assume the solids on the tarp weigh 110 pounds.

2. Convert the pounds to wet tons per acre

- a. First, convert the pounds collected to pounds per acre by multiplying 110 by 435. This is equivalent to 47,850 pounds per acre.

$$110 \text{ lb} \times 435 = 47,850 \text{ lb}/\text{acre}$$

- b. Now, convert the pounds per acre to wet tons per acre by dividing 47,850 by 2,000 (the number of



Figure 3. Place a tarp or piece of plastic in the field and apply solids over the area.

pounds per ton). The result is 23.9 wet tons per acre.

$$\frac{47,850 \text{ lb/acre}}{2,000} = 23.9 \text{ wet tons/acre}$$

3. Calculate the nitrogen application rate

If the concentration of nitrogen is 5 pounds per wet ton, the rate of nitrogen applied is 119 pounds of nitrogen per acre.

$$23.9 \text{ wet tons/acre} \times 5 \text{ lb N/wet ton} = 119 \text{ lb N/acre}$$

Manure sampling and testing

Having a sample analyzed by a lab is the best way to determine nutrient concentration. Testing manure for nutrient content is relatively easy; however, it can be difficult to get one sample that represents the nutrient concentration of the entire load of manure. Nutrient content can vary considerably within a load, and agitation usually is inadequate to achieve thorough mixing. Analyzing the samples taken during the calibration process is the most desirable method, especially when testing for nitrogen, because these values should represent what actually reaches the soil.

This method accounts for nutrient losses that occur during storage and application.

Take samples from a liquid tank or lagoon only after agitation.

Book values (e.g., estimates published in Extension publications) are a reasonable approach if testing is not feasible, but actual values vary from operation to operation depending on water added, feed composition (both quality and quantity), age and stage of lactation of the cattle, and the manure storage system.

For more information

There are a number of other helpful Oregon State University Extension Service publications available online at <http://extension.oregonstate.edu/catalog/>

- *Laboratories Serving Oregon: Soil, Water, Plant Tissue, and Feed Analysis* (EM 8677)
- *Nutrient Management for Dairy Production: Manure Application Rates for Forage Production*, (EM 8585-E)

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