

Calculating Dairy Manure Nutrient Application Rates

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

This publication describes how to calibrate waste-handling equipment and to calculate nutrient application rates. It covers typical equipment found on dairies and uses nitrogen in the examples. The same techniques can be used with phosphorus.

Generally, it is desirable to apply no more than 100 pounds N per acre at a time. See the publications listed under “For more information” on page 6 to learn how to determine appropriate nutrient application rates for your situation.



Figure 1. Place several straight-sided, flat-bottom buckets in the area where the gun is to apply liquid.

Doing the calculations

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

- The concentration of nitrogen in the manure—For example, if you apply 100 pounds or 100 gallons of manure, you must know how much nitrogen is in each pound or gallon. Having a sample analyzed by a lab is the best way to determine nutrient concentration, but using book values usually puts you in the ballpark.
- How much manure (pounds or gallons) you have applied
- The area (square feet or acres) that received the application



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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 (Figure 1). 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. Let's say you applied $\frac{1}{2}$ 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 big gun covers a circle 180 feet across, the radius is 90 feet. Multiply 90 ft x 90 ft x 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:

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

3. Convert the inches applied to gallons. If you had an average of $\frac{1}{2}$ inch of liquid manure in your buckets, you can assume

you applied $\frac{1}{2}$ inch over the 25,434 square feet.

a. First, convert the square feet to cubic feet by dividing 25,434 by 24 ($\frac{1}{2}$ inch in the bucket is $\frac{1}{24}$ 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 7,948 gallons pumped in 30 minutes.

4. Determine the pumping rate. Divide 7,948 gallons by 30 minutes. Your pumping rate is 265 gallons per minute.

5. Calculate the total amount of nitrogen applied. If the nitrogen concentration of the manure is 10 pounds per 1,000 gallons, and you applied 7,948 gallons, then you applied 79 pounds of nitrogen.

$$\frac{7,948 \text{ gal} \times 10 \text{ lb N}}{1,000 \text{ gal}} = 79 \text{ lb N}$$

6. Calculate the amount of nitrogen applied per acre. Since you covered 0.58 acres, you applied the equivalent of 137 pounds of nitrogen per acre.

$$\frac{79 \text{ lb N}}{0.58 \text{ acres}} = 137 \text{ lb per acre}$$



Figure 2. Calibrating a traveler involves the same principles described for the stationary gun, but you adjust for the speed of the traveler.

Calculating rates with a traveling gun

Calibrating a traveler involves the same principles described for the stationary gun, but you adjust for the speed of the traveler (Figure 2).

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. Let's say, for example, that your application is 240 feet wide, each pass is 1,000 feet, and the traveler moves at 6 feet per minute.

1. Calculate the area covered. Multiply the 240-foot width by the 1,000-foot pass to determine that you covered 240,000 square feet. This represents 5.5 acres.

$$\frac{240,000 \text{ ft}^2}{43,560 \text{ ft}^2 \text{ per acre}} = 5.5 \text{ acres}$$

2. Measure the amount of liquid applied. During the application, place several buckets throughout the pass area. 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 to determine how many inches you applied. For example, let's say your application averaged $\frac{1}{3}$ inch.

3. Convert the inches applied to gallons.

a. 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.

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

b. 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.

4. Calculate the total amount of nitrogen applied. If the manure contains 8 pounds of nitrogen (N) per 1,000 gallons, and you applied 50,002 gallons, then you applied 400 pounds N.

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

5. Calculate the amount of N applied per acre. Four hundred pounds of N applied over 5.5 acres equals around 73 pounds per acre.

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

6. 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 (see Table 1 for an example). In the example above, the speed was 6 feet per minute. At 3 feet per minute, the application rate would be twice that at 6 feet, or 146 pounds N per acre.

7. Estimate the pump rate per minute. At 6 feet per minute, it takes 166 minutes to complete a 1,000-foot pass.

$$\frac{1,000 \text{ ft}}{6 \text{ ft per minute}} = 166 \text{ minutes}$$

Divide the total gallons pumped by the total minutes pumped. For this example, 50,002 gallons divided by 166 minutes equals 301 gallons per minute.

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
4.0	0.5 inches	109	300	600	900
6.0	0.33 inches	73	200	400	600
8.0	0.25 inches	55	150	300	450
10.0	0.20 inches	44	120	240	360

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					
4.0					
6.0					
8.0					
10.0					

Calculating rates with a liquid wagon

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. For example:

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.

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



Figure 3. Place several trays, pans, or short buckets in the field to catch liquid applied with one pass.

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.

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

3. Calculate the per-acre N application rate.

If the manure has a nitrogen concentration of 10 pounds N per 1,000 gallons, you applied 90 pounds of N 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. For example:

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 3). 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. Let's assume you applied $\frac{1}{2}$ inch.

2. Convert the inches applied to gallons applied per acre.

- a. 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.

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

- 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.

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

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

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 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 N per 100 cubic feet, you are applying 40 pounds of N per load of solids.

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



Figure 4. Place a tarp or piece of plastic in the field and apply solids over the area.

- 3. Calculate the amount of N applied to the field.** Record the number of loads hauled on each field. Multiply the number of loads by the amount of N per load. For example, if you hauled 25 loads of solids, multiply 25 loads by 40 pounds N per load, for a total application of 1,000 pounds N.

- 4. Calculate the number of pounds of N applied per acre.** Divide the total amount of N applied by the number of acres, in this example 10 acres.

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

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. For example:

- 1. Measure the amount of solids applied.**

Place a tarp or piece of plastic in the field and apply solids over the area (Figure 4). A 10' x 10' tarp measures 100 square feet, which represents $\frac{1}{435}$ of an acre.

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

After spreading across the sample area, fold the tarp and weigh the solids collected on it. 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 lb per acre.

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

- b. Now**, convert the pounds per acre to wet tons per acre by dividing 47,850 by 2,000 (the number of 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 N applied is 119 pounds N per acre.

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

Manure sampling and testing

Testing manure for nutrient content is relatively easy. However, it can be a major problem to get one sample that represents the nutrient concentration of the 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 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

Hart, J., *A List of Analytical Laboratories Serving Oregon*, EM 8677 (Oregon State University, Corvallis, revised 2000). No charge.

Hart, J., M. Gangwer, M. Graham, and E. Marx, *Dairy Manure as a Fertilizer Source*, EM 8586 (Oregon State University, Corvallis, published 1995, reprinted 1997). 75¢

Hart, J., E.S. Marx, and M. Gangwer, *Manure Application Rates for Forage Production*, EM 8585 (Oregon State University, Corvallis, published 1996, reprinted 1997). \$1.50

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