

Keeping Track of Manure Nutrients in Dairy Pastures

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Keeping track of nutrient levels in dairy pastures has become an important part of farm management plans. The current recommendation is to fertilize pastures at a level to replace, in equal measure, the nutrients removed through grazing or cutting each year.

The Confined Animal Feeding Operations Program (CAFO) run by the Oregon Department of Agriculture assumes that most livestock facilities apply manure at agronomic rates for nitrogen. Thus, they expect CAFO operations to make sure the amount of nitrogen applied to a field each year equals the amount removed.

For operations with grazing animals, determining manure application rates and forage consumption can be challenging. This publication will help you work through this process.

In concept, tracking nitrogen balance is simple: the grazing animal adds nitrogen in the form of manure and urine and removes it in the form of protein in the grass grazed. To quantify these values, you need to determine both how much manure was applied and the amount and quality (percentage nitrogen content) of grass grazed.

The variables include:

- Manure generated: number of animals and the amount of time spent in each field
- Quantity of forage removed through grazing and cutting
- Quality of forage removed: percent protein (i.e., percent nitrogen)
- Amount of manure stored and spread from the confinement facility
- Acreage of each pasture unit
- Calibration of waste-handling equipment

Estimating manure generated

The nitrogen content of dairy manure is well documented, but these values vary depending on feed intake. Table 1 shows the direct relationship between nutrient intake and excretion.

By estimating the percentage of the day cows spend in the field, you can calculate the amount of the day's waste applied as fertilizer. Note in Table 1 that the amount of nutrients excreted by a cow can be estimated based on her milk production or feed intake.

Table 1. – Estimated daily nitrogen (N) and phosphorus (P) excretion.

Milk Production	100 lb/day	70 lb/day	50 lb/day	Dry
Intake/day	56 lb	46 lb	39 lb	25 lb
Total N, lb/day waste	0.9 lb/day	0.8 lb/day	0.65 lb/day	0.4 lb/day
Total P, lb/day (diet 0.45% P)	0.151 lb/day	0.138 lb/day	0.126 lb/day	0.113 lb/day

Source: H.H. Van Horn et al., 1999.

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For example, if a Holstein cow is grazed for 9 hours at night and 9 hours during the day, she spends 75 percent of her time in the field and deposits 75 percent of her daily waste production there. If she excretes 0.8 lb of nitrogen per day, she applies 0.6 lb of nitrogen to the field. The remaining 25 percent, or 0.2 lb, is deposited in the confinement facility.

If you graze 100 Holstein cows in Field 1, a 4-acre field, for 2 days at 18 hours per day, they will apply 120 lb of nitrogen to the field, or 30 lb per acre.

Measuring quantity and quality of grass consumed by the animals

There are four common ways to measure standing grass volume before and after grazing to determine the amount of nutrient removed.

Clipping and weighing

The most accurate method is to clip a small subsample of the field before grazing. Use a hoop to calculate how many square feet you are clipping; throw the hoop at random, then clip the standing forage inside the ring down to the ground. Figure 1 shows a hoop that measures 1 square foot. Cut at least 10 to 15 sample plots per field, depending on the size of the field and the variation in the height of existing forage. The larger the field, or the greater the variation in forage height, the more samples you need. The more uniform your forage height, the more accurate your estimate.

By calculating the total square feet clipped and weighing the forage, you can determine how many pounds of total feed were standing per acre before grazing. An acre is 43,560 sq ft. Divide your total clipped area into 43,560; then multiply the answer times the weight of the forage clipped to determine your estimated pounds of standing wet grass per acre. Measuring again after grazing tells you how much forage was removed.

To determine pounds of dry matter (DM) per acre, however, you need to know what percentage of the forage is dry matter versus moisture. A commercial forage lab can analyze the forage, but the following process lets you perform a quick moisture test at home with a small scale and a microwave oven.

1. Weigh a paper bag large enough to hold 4 ounces of the clipped forage. Write down the weight as value “A.”
2. Place about 4 ounces, or 100 grams, of your forage into the bag and weigh again. This becomes value “B.”
3. Place a cup of water in the corner of the microwave oven and the filled bag in the center. Dry the sample at a



Figure 1.—By clipping several 1-square-foot samples of forage before and after grazing, you can estimate the amount of forage removed by grazing.

medium power setting for 3 minutes. Remove the sample and stir gently, then dry for another 1½ minutes. Stir again, then dry for another minute.

4. The sample should be getting dry and crisp. Weigh the sample and bag, stir again gently, then dry for another 30 seconds. Continue 30-second drying and weighing intervals until the weight measurement reads the same twice. Record the final weight as value “C.” If the sample begins to char, use the previous measurement.
5. Calculate the dry matter content using this formula:

$$\%DM = \frac{\text{Total dry weight “C”} - \text{bag weight “A”} \times 100}{\text{Total wet weight “B”} - \text{bag weight “A”}}$$

Now you can calculate the total dry matter in the field before and after grazing by multiplying the percent dry matter times the forage removed by grazing. In our example, the calculations show 2,400 lb of dry matter per acre before and 1,200 lb after grazing 100 cows for 2 days at 18 hours per day. Therefore, for 4-acre Field 1, the cows removed a total of 4,800 lb of dry matter.

Rising plate meter

The second most common method of measuring forage in the field involves a rising plate meter (Figure 2). This device estimates standing forage dry matter by accounting for pasture height and density. The electronic meter pictured allows the operator to select the “cover equations” that most closely represent existing pasture conditions. To determine the correct cover equation, take 30 to 50 pasture clipping samples per paddock to establish an average reading. Once calibrated, the device will provide standing forage measurements in pounds of dry matter per acre or kilograms per hectare. Most commercially available rising plate meters are made in New Zealand.

Yard stick

The third method for calculating standing forage uses a yardstick. By measuring the standing height of the forage, you can make an educated estimate of the total pounds of dry matter. This method does not account for stand density, so the more uniform your pastures, the more accurate your estimate will be.

To use this method, measure the height of the pasture (Figure 3). Use the clipping and weighing method to determine how many pounds of dry matter are in the standing forage per acre. Divide this value by the number of inches in height to calculate an estimated per-inch value. For example, if your pasture measures on average 12 inches tall and you calculate that there are 3,000 lb of dry matter per acre, your pasture averages 250 lb of dry matter per acre-inch.

It is important to complete these steps several times to account for variations in your technique and in the fields. Common values for good ryegrass pastures range from 250 to 300 lb DM per inch for well-established pastures. In our clipping and weighing example, Field 1 had 2,400 lb of dry matter per acre before grazing, so the pasture would have been around 8 inches tall. After grazing, we had 1,200 lb of dry matter left, so the pasture should have been around 4 inches tall.

Capacitance meter

The fourth method for calculating standing forage is with a capacitance meter (Figure 4), an electronic device that measures dry matter in standing forage as you walk

across the field. Take at least 30 to 40 measurements before turning the animals into the field and immediately after the period of grazing. Like the rising plate meter, the capacitance meter provides measurements in pounds of dry matter per acre or kilograms per hectare. This equipment also is available from many New Zealand companies.

Testing protein levels

If you periodically test the protein level of the forage grazed, you can use this value to determine nitrogen content. For example, if Field 1 tests 20 percent protein, a ton of dry matter (2,000 lb) contains 400 lb of protein.

Nitrogen is a significant component of protein, and nitrogen levels can be determined with a simple calculation. If you divide the protein content (in this case, 400 lb) by 6.25, the resulting figure represents the approximate amount of nitrogen removed per dry matter ton, or 64 lb. Therefore, extending our earlier example of 4,800 lb of forage dry matter removed, we can make the following calculation: 2.4 tons x 64 lb nitrogen per ton = 154 lb of nitrogen removed from the 4-acre Field 1, or 38 lb of nitrogen per acre. Table 2 (page 4) shows the relationship between percentage of protein and pounds of nitrogen content in dry matter.

Determining the net N balance

In our example, the grazing cows deposited 120 lb of nitrogen and removed 154 lb in the 4-acre field. Therefore, there was a net loss of 34 lb of nitrogen from the field during this grazing session, an 8.5-lb loss per acre.



Figure 2.—The electronic rising plate meter estimates standing forage dry matter, accounting for pasture height and density.



Figure 3.—By measuring the height of forage, you can estimate the total pounds of dry matter in a pasture.



Figure 4.—A capacitance meter measures dry matter in standing forage as you walk across the field.

Table 2. – Pounds of nitrogen removed as crude protein increases.

Protein	8%	12%	16%	20%	24%	28%
Pounds of N per ton of dry matter	25.6	38.4	51.2	64	76.8	89.6

Table 3.—Example record keeping system (Field 1, 4 acres).

Date	Action	DM removed/ per acre	N removed/ field	N removed/ acre	N applied to field	N applied/ acre	N balance for field	N balance/ acre
6/6	Grazed 100 cows	1,200	-154	-38	120	30.0	-34	-8.5
6/9	Pumped manure	—	—	—	150	37.5	116	29.5

Adding nutrients from the confinement facility

The last component to account for are the nutrients applied from the confinement facility, including parlor waste and all other manure gathered throughout the year. By calibrating your waste-handling equipment and determining the nutrient content of the waste applied, you can successfully account for the application of manure in your field's nutrient balance.

For example, if you pump 25,000 gallons of manure evenly over Field 1 and your manure has 6 lb of nitrogen per 1,000 gallons, you would apply 150 lb of nitrogen to the 4-acre field, or 37.5 lb N/acre. Since the net balance after grazing in Field 1 was -8.5 lb N/acre, you would have restored the nutrient balance to a positive 29.5 lb N/acre.

Conclusions

You can determine the net balance of nitrogen in grazing situations by calculating the quantity applied and subtracting the quantity removed. It is important to realize the numbers you generate are based on estimates; exact values aren't possible when dealing with nitrogen in dairy pastures. Soil sampling in the fall is an excellent way to monitor success of a balanced fertilization program. See EC 628, *Soil Sampling for Home Gardens and Small Acreages*.

Measuring application and removal of nutrients is important in an effective manure fertilization program. Achieving balance using this method will move you toward agronomic application rates and should both increase productivity and protect the environment from over-application of manure nutrients.

For more information

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