Lesson 12

Feeding Dairy Cows to Reduce Nutrient Excretion

By Rick Grant, University of Nebraska, and Stanley (Lee) Telega, Cornell University
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Disclaimer
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Intended Outcomes
The participants will

• Understand the impact of dietary nutrient content on nitrogen (N), phosphorus (P), and potassium (K) excretion by dairy cows.
• Understand the basic idea of nutrient balance on dairy farms.
• Learn what the recommended requirements are of N, P, and K for dairy cows to avoid overfeeding these nutrients.
• Learn feeding practices that will maximize animal performance and minimize nutrient excretion.
• Understand the land requirements needed to manage the manure nutrients on dairy farms.

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Activities
The participants will

• Calculate the amount of N, P, and K excreted by cows in their herd.
• Conduct a self-assessment of how well their herd minimizes nutrient excretion and evaluate approaches to improve their feeding program.
• Learn about several websites with useful information to help them calculate nutrient excretion by their herd, calculate land base needed for managing the manure, and to understand the consequences of overfeeding N, P, or K.

PROJECT STATEMENT
This educational program, Livestock and Poultry Environmental Stewardship, consists of lessons arranged into the following six modules:
• Introduction
• Animal Dietary Strategies
• Manure Storage and Treatment
• Land Application and Nutrient Management
• Outdoor Air Quality
• Related Issues

Note: Page numbers highlighted in green are linked to corresponding text.
Reducing N, P, and K Excretion: the Challenge for Dairy Producers

Increasingly, our society demands livestock production systems that not only produce economic, high-quality food products but also minimize negative environmental impacts. Feeding management has improved continuously and helps to explain steadily increasing milk production. The future challenge for dairy producers and nutritionists will be to properly formulate rations for high production levels while simultaneously minimizing the environmental impact of excessive nitrogen (N), phosphorus (P), and potassium (K) excretion in the manure. A realistic approach will be to keep formulation of profitable, balanced rations as the primary goal but to also give substantial consideration to adjusting formulations and feeding strategy, minimizing any negative environmental impact.

In many cases, a properly formulated ration that precisely meets the cow’s requirements for milk production, maintenance, and gestation will also minimize excessive N, P, and K excretion in the manure and urine. Increasingly, we have ration formulation software that allows us to accomplish this goal.

This lesson will present the basics of feeding dairy cows to minimize N, P, and K excretion into the environment. In addition, key concepts of managing manure nutrients on dairy operations are presented.

The next section provides an overview of the key concepts of nutrient balance on dairy operations. The goal is to understand the nutrient inputs, outputs, and consequently, the percentage of nutrients that remain on the farm or are lost into the environment.

Key Concepts of Nutrient Balance on a Dairy Farm

An assessment of nutrient balance on a dairy farm allows you to determine management options that increase nutrient recycling from cropland to the cattle and back to crops again (Klausner 1993). A more detailed discussion of whole farm nutrient balance can be found in Lesson 2, Whole Farm Nutrient Planning.

Nutrient management decisions must relate to the movement of nutrients onto the farm, movement of nutrients within the farm system (including all cropland owned and leased by the dairy), and movement of nutrients out of the farm system. Figure 12-1 illustrates a simplified flow of nutrients on a typical dairy farm. Usually, N, P, K, and other nutrients are brought into the farm system via purchased feeds and fertilizer, although N also enters the farm via N fixation by legumes and rainfall. These same nutrients leave the farm in products sold such as milk, meat, and crops. The magnitude of any resulting losses is driven by the difference in inputs and outputs.

Nutrients normally become concentrated on dairy farms because more are brought into the farm system than leave in the products sold. Table 12-1 illustrates the mass N and P balances for several dairy farms in New York as summarized by Klausner (1993).

Although the actual values for N and P inputs and outputs will vary, depending on the farm’s location in the United States and the resources available, Table 12-1 does provide a good overview of the typical capture of nutrients on a dairy farm. For instance, notice that the percentage of N remaining on these farms ranged from 64% to 76% and was not related to
Figure 12-1. A simplified diagram of nutrient flow on a typical dairy operation.
Source: Klausner 1993.


<table>
<thead>
<tr>
<th>Size of Dairy, Number of Cows</th>
<th>45</th>
<th>320</th>
<th>500</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Input</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Purchased fertilizer</td>
<td>1.0</td>
<td>13.5</td>
<td>26.1</td>
</tr>
<tr>
<td>Purchased feed</td>
<td>3.8</td>
<td>43.8</td>
<td>78.5</td>
</tr>
<tr>
<td>N fixation by legumes</td>
<td>1.3</td>
<td>14.6</td>
<td>13.9</td>
</tr>
<tr>
<td>Purchased cattle</td>
<td>0</td>
<td>0.1</td>
<td>0</td>
</tr>
<tr>
<td><strong>Total inputs</strong></td>
<td>6.1</td>
<td>72.0</td>
<td>118.5</td>
</tr>
<tr>
<td><strong>Output</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Milk</td>
<td>2.0</td>
<td>18.6</td>
<td>26.4</td>
</tr>
<tr>
<td>Cattle sold</td>
<td>0.1</td>
<td>1.9</td>
<td>1.9</td>
</tr>
<tr>
<td>Crops sold</td>
<td>0.1</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td><strong>Total outputs</strong></td>
<td>2.2</td>
<td>20.5</td>
<td>28.3</td>
</tr>
<tr>
<td><strong>Remainder</strong></td>
<td>3.9 (6.1-2.2)</td>
<td>51.5 (72-20.5)</td>
<td>90.2 (29.2-28.3)</td>
</tr>
<tr>
<td>% Remaining on farm</td>
<td>64%</td>
<td>71%</td>
<td>76%</td>
</tr>
<tr>
<td><strong>Input</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Purchased fertilizer</td>
<td>1.2</td>
<td>2.0</td>
<td>5.5</td>
</tr>
<tr>
<td>Purchased feed</td>
<td>1.0</td>
<td>8.4</td>
<td>14.2</td>
</tr>
<tr>
<td>Purchased cattle</td>
<td>0</td>
<td>0.03</td>
<td>0</td>
</tr>
<tr>
<td><strong>Total inputs</strong></td>
<td>2.2</td>
<td>10.4</td>
<td>24.2</td>
</tr>
<tr>
<td><strong>Output</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Milk</td>
<td>0.36</td>
<td>3.8</td>
<td>5.5</td>
</tr>
<tr>
<td>Cattle sold</td>
<td>0.05</td>
<td>0.5</td>
<td>0.5</td>
</tr>
<tr>
<td>Crops sold</td>
<td>0.01</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td><strong>Total outputs</strong></td>
<td>0.43</td>
<td>4.3</td>
<td>6.0</td>
</tr>
<tr>
<td><strong>Remainder</strong></td>
<td>1.8 (2.2-.43)</td>
<td>6.2 (10.4-4.3)</td>
<td>18.2 (24.2-6)</td>
</tr>
<tr>
<td>% Remaining on farm</td>
<td>81%</td>
<td>59%</td>
<td>75%</td>
</tr>
</tbody>
</table>

Adapted from Klausner 1993.
the dairy’s size. But, with greater herd size, more N (or P) must be managed and therefore more acres of cropland will be needed to effectively use the nutrients from the dairy. The mass balance for P is similar to N; in each case, a large percentage of the P that is brought onto the farm each year remains on the farm and accumulates over years. Although data are lacking, it is possible that microminerals (such as sodium and chloride) also accumulate.

Since nutrient accumulation is common on dairy operations, you need to develop a nutrient management plan that ensures efficient nutrient use by and minimal environmental impact from the cattle and crops. Keep in mind that these mass balances are only estimates of the actual nutrient status of a dairy. To develop a specific mass balance for your dairy, use the tools found in Lesson 2, Whole Farm Nutrient Planning.

Follow the steps below to minimize the flow of N, P, K, and other nutrient inputs onto your farm:

1. Determine the actual nutrient requirements of the cattle and crops before making feed and fertilizer purchases.
2. Sample and analyze feeds during ration formulation; do not rely on “book values.”
3. Use soil testing to determine crop requirements.

To reduce the amount of feed purchased on most dairies, maximize the harvest of high-quality forages. When more nutrients come from homegrown forages, then fewer nutrients must be purchased and brought onto the farm.

*Remember that purchased feeds and fertilizers are a major route for nutrients to enter the farm. Each purchase must be scrutinized carefully to avoid unnecessary accumulation of nutrients on the dairy.*

**How Much N, P, and K Does a Dairy Cow Excrete?**

When manure management systems are designed, standard excretion amounts for N, P, and K are often used. These values have been tabulated by the American Society of Agricultural Engineers (1990) and estimate the daily and yearly excretion of N, P, and K based on the cow’s body weight and also provide reasonably good estimates of nutrient excretion. However, these standard values do not account for the large variation among dairy farms in feed intake levels, rations fed, feeding programs, and consequently, actual nutrient excretion levels.

Research conducted at the University of Florida in the early 1990s (Morse et al. 1992; Tomlinson 1992) showed that N and P excretion by dairy cows varies substantially with the amount and rumen degradability of N (crude protein, CP) and the P fed in the ration. In fact, these researchers concluded that the amount of N and P excreted daily can be reasonably predicted based on daily intake of N and P, dry matter intake, and milk production.

Table 12-2 shows the daily and yearly excretion of N, P, and K by 1,400-pound Holstein cows. Clearly, the amount of N, P, and K in the diet has a dramatic effect on the yearly excretion of these nutrients. For instance, increasing the amount of P from 0.40% to 0.60% of the ration dry matter increased excretion of P from 40 to 69 pounds/cow yearly. According to a 1998 survey of dairy nutritionists in Nebraska, this difference of almost 30 lbs in P excretion accurately reflects the actual range in P levels that are currently being fed in the dairy industry. Surveys in other states such as
Texas, Florida, and Wisconsin confirm these observations (Morse 1989, Sansinena et al. 1999), although the degree of P oversupplementation may be less in western states (Meyer 2001). Even though the actual P requirement of high-producing dairy cows is near 0.40% of ration dry matter (NRC 2001), some U.S. farmers commonly feed in excess of 0.50%. Clearly, this is one feeding practice that can be modified to have a large impact on P excretion.

Table 12-3 illustrates a straightforward method to calculate the amount of N, P, or K produced by a lactating herd of dairy cows based on nutrient intake and level of production. Although simplified, this approach allows you to obtain a reasonably accurate estimate of N and P excretion for planning purposes.

In the example provided in Table 12-3, you calculate the total N, P, and K excreted by a group of 100 high-producing dairy cows. Following are the steps needed to manually complete this worksheet for any group of cattle on your farm:

1. List the groups of cattle on your farm with the number of cattle in each group. In the example in Table 12-3, a group of 100 dairy cows is producing 90 pounds of milk per day.
2. Enter the daily feed intake (dry basis) for the entire group (5,500 lbs/d for the example).
3. Enter the crude protein (CP), N, P, and K content of the ration fed to this group in decimal form [0.175 (17.5%) CP, 0.028 (2.8%) N, 0.0040 (0.40%) P, and 0.015 (1.5%) K for the example].
4. Total the amount of N, P, and K consumed daily by this group of cattle by multiplying daily dry matter intake by nutrient content (154 lbs/d N, 22 lbs/d P, and 82.5 lbs/d K for the example).
5. If the group of cattle is gaining weight, then you can calculate the amount of N, P, and K that is retained in the body tissue of those cattle. To do this, multiply the number of cattle in the group x the average daily gain x the content of N, P, and K in the tissue (provided in the table). In the example, because the high-producing cows are not gaining weight, there is no retention of N, P, or K. Most lactating dairy cows will begin to regain lost body weight by 70 to 84 days in milk.

Table 12-2. Daily and yearly excretion of N, P, and K by 1,400-pound Holstein dairy cow.

<table>
<thead>
<tr>
<th></th>
<th>ASAE1</th>
<th>0-30 DIM2</th>
<th>31-100 DIM</th>
<th>101-305 DIM</th>
<th>60-day Dry Period</th>
<th>Yearly Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Milk, pounds/cow</td>
<td></td>
<td>100</td>
<td>70</td>
<td>50</td>
<td>Dry</td>
<td>21,750 lbs</td>
</tr>
<tr>
<td>DMI3, pounds/cow</td>
<td></td>
<td>55.8</td>
<td>46.3</td>
<td>39.2</td>
<td>25.2</td>
<td>14,462 lbs</td>
</tr>
<tr>
<td>Pounds N excreted/day</td>
<td></td>
<td>0.63</td>
<td>0.89</td>
<td>0.73</td>
<td>0.60</td>
<td>0.36</td>
</tr>
<tr>
<td>Total N (low protein</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>lbs/cow/yr</td>
</tr>
<tr>
<td>degradability)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>223</td>
</tr>
<tr>
<td>Total N (high protein</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>lbs/cow/yr</td>
</tr>
<tr>
<td>degradability)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>260</td>
</tr>
<tr>
<td>Pounds P excreted/day</td>
<td></td>
<td>0.132</td>
<td>0.123</td>
<td>0.115</td>
<td>0.107</td>
<td>0.101</td>
</tr>
<tr>
<td>0.40% P in diet</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>lbs/cow/yr</td>
</tr>
<tr>
<td>0.45% P in diet</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>40</td>
</tr>
<tr>
<td>0.60% P in diet</td>
<td></td>
<td>0.132</td>
<td>0.151</td>
<td>0.138</td>
<td>0.136</td>
<td>0.103</td>
</tr>
<tr>
<td>Pounds K excreted/day</td>
<td></td>
<td>0.040</td>
<td>0.296</td>
<td>0.265</td>
<td>0.239</td>
<td>0.201</td>
</tr>
<tr>
<td>0.80% K in diet</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>lbs/cow/yr</td>
</tr>
<tr>
<td>1.2% K in diet</td>
<td></td>
<td>0.406</td>
<td>0.519</td>
<td>0.450</td>
<td>0.396</td>
<td>0.302</td>
</tr>
<tr>
<td>1 American Society of Agricultural Engineers</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2 Days in milk</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3 Dry matter intake</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
6. Calculate the amount of N, P, and K secreted in the milk (45 lbs/d N, 9.0 lbs/d P, and 13.5 lbs/d K for the example).
7. Finally, calculate the total N, P, and K excretion by each group of cattle for a selected time period. In the example, the 100 cows are in the group for 100 days. The N, P, and K retained in tissue (0 in this example) plus the N, P, and K secreted in milk are subtracted from the total N, P, and K consumed. In the example, this results in excretion of 10,900 lbs N; 1,300 lbs P; and 6,900 lbs K over the time period of 100 days by these 100 lactating dairy cows.

Table 12-3. Total manure nutrients produced by dairy cattle based upon ration nutrients.

<table>
<thead>
<tr>
<th>Animal Group</th>
<th>Feed Nutrient Intake</th>
<th>B. Feed Nutrient Concentration</th>
<th>C. Total Nutrient in Feed, lbs = A x B</th>
</tr>
</thead>
<tbody>
<tr>
<td>Example: 100 high-producing dairy cows</td>
<td>5,500 lbs DM/d</td>
<td>Protein</td>
<td>N¹</td>
</tr>
<tr>
<td></td>
<td></td>
<td>0.175</td>
<td>0.175 ÷ 6.25 = 0.028</td>
</tr>
</tbody>
</table>

Table 12-3 continued.

Nutrients Retained by Animal (if cow is gaining weight) or Secreted in Milk

<table>
<thead>
<tr>
<th>Animal Group</th>
<th>D. Number of Animals</th>
<th>E. Average Daily Gain</th>
<th>F. Live Weight Nutrient Concentration</th>
<th>G. Nutrients Retained by Animal, lbs = D x E x F</th>
</tr>
</thead>
<tbody>
<tr>
<td>Example: Dairy cows</td>
<td>100 high-producing dairy cows</td>
<td>0</td>
<td>100 x 0 x 0.012 = 0</td>
<td>100 x 0 x 0.0070 = 0</td>
</tr>
</tbody>
</table>

Nutrient Excretion by Livestock

<table>
<thead>
<tr>
<th>Animal Group</th>
<th>K. Days Fed per Year</th>
<th>Annual Nutrient Excretion in Elemental Form = K x (C - G) or = K x (C + J) or both</th>
</tr>
</thead>
<tbody>
<tr>
<td>Example: 100 high-producing dairy cows</td>
<td>100 days</td>
<td>N</td>
</tr>
<tr>
<td></td>
<td></td>
<td>100 x (154 - 0 - 45) = 10,900 lbs</td>
</tr>
</tbody>
</table>

¹N in feed = Protein ÷ 6.25 ²N in milk = Protein ÷ 6.45. Assumes 3.2% protein in milk. ³lbs P₂O₅ = lbs P x 2.27 lbs  K₂O = lbs K x 1.2
A similar method for estimating dairy cow N, P, and K output, a spreadsheet developed at the University of Nebraska, is available at the following website: <http://www.ianr.unl.edu/manure>. This Excel® spreadsheet estimates the excretion of N, P, and K by dairy cows, the quantity of nutrients remaining after losses, and the land needs for using these nutrients at agronomic rates. To generate more accurate estimates of nutrient excretion than shown in Table 12-3 and develop a nutrient use plan, you will need to enter the following information into the spreadsheet:

- Number of cows
- Daily feed intake
- Dietary CP, P, and K
- Daily milk production
- Cow body weight

This user-friendly spreadsheet is based on data reported by University of Florida researchers (Van Horn 1992) and summarized in Table 12-2. The next section briefly describes the land requirements needed to manage manure nutrients on dairy operations and the impact of dietary N and P on the land base needed.

**Land Requirements for Managing Manure Nutrients on Dairy Operations**

If the owned or managed land available for manure application is inadequate for the agronomic application of manure, dairy producers must identify sufficient land to utilize N and P. The P-based management of manure requires much more land base than N-based management. Presently, land requirements are commonly regulated based on N, but growing pressure exists for greater regulation of P buildup in the soil. Many states are developing a Phosphorus Index to assess soil P buildup in fields and the potential for P transport from that field. Other states are considering an environmental soil test P level above which no additional manure or fertilizer P can be used in growing the crop on that field. More details on this topic can be found in Lesson 34, Phosphorus Management for Agriculture and the Environment.

Many factors influence manure nutrient excretion and the eventual land base needed for agronomic nutrient application. Decisions regarding ration formulation and feeding strategies (discussed later in this lesson) play a critical role in determining nutrient excretion by dairy cattle.

As milk production of dairy cattle increases, so do the nutrient requirements and the nutrients they excrete. For herds producing between 70 and 100 lbs of milk per cow/day, a 100-cow group will require between 140 and 170 acres to manage the N in the manure, depending on crop rotation and yields (Koelsch 1999). Consequently, to successfully manage N in the manure, you should have access to approximately 1.5 acres per cow. With a greater focus on environmental problems associated with excess soil P levels, access to at least 2.25 acres per cow will be necessary (Koelsch 1999).

The content of protein and P in the ration significantly affects excretion in the manure, and consequently, the land base needed for manure application. Protein not used for milk production or cattle maintenance and growth is excreted as urea or organic N in the manure. Typically, 70% of the N fed to animals as protein is excreted in a diet that is formulated to National Research Council (NRC) (2001) guidelines. Feeding in excess of the NRC
guidelines only adds to the N excreted in the manure. Two examples illustrate the tremendous impact that dietary content of N and P have on land needed. A diet containing 19.5% CP (based on alfalfa with no supplemental escape CP) results in about 20% more N in the manure than a diet with only 17.0% CP (containing supplemental escape CP so that total ration CP can be reduced). In this example, 20% more land is needed for manure management for cows fed the higher CP diet. For a 100-cow group of cows, an additional 6 to 25 acres is needed to manage the N in manure. Commonly observed ranges for P levels in dairy rations can exert an even greater impact on land requirements. A ration containing 0.52% P results in 30% more land needed than a 0.43% P diet. Even though the 0.43% P diet meets the cow’s requirements, for a 100-cow group, an additional 50 or more acres are needed for managing the extra P.

These examples give you an idea of the effect of ration formulation on land needed for manure application. Obviously, actual land application area needs will vary for each farm for a variety of reasons. To develop an estimate of land needs for any individual farm, use the “Manure Nutrient Inventory” spreadsheet discussed in the previous section. If managed improperly, manure nutrients represent a critical environmental threat. Dairy producers should have access to at least 1.5 acres of land per cow to manage manure in a N-based manure management system utilizing manure storage. Approximately 0.4 acres per cow are needed to manage N for a system with an anaerobic lagoon.

The remainder of this lesson addresses specific issues of N, P, and K nutrition of dairy cows and ration formulation. The goal is to give you the tools to develop a feeding program that minimizes N, P, and K excretion by each group of cattle on your dairy farm.

**Phosphorus Requirements, Sources, and Excretion in Dairy Cows**

Since the 1960s, several researchers have examined P metabolism in the lactating dairy cow. In the previous NRC (1989) publication on dairy cattle nutrient requirements, P requirements were increased by 10% to 22% to adjust for dietary P availability in common feeds. This publication gives the P requirement as 0.49% for the first 3 weeks of lactation and then 0.38% to 0.42% for cows in early to midlactation.

Recent research from the U.S. Dairy Forage Research Center in Madison, Wisconsin, confirms that high-producing dairy cows require approximately 0.40% P in the dietary dry matter for optimal milk production and reproductive performance. Although it is a common practice to feed 0.50% to 0.60% P in some parts of the United States, these controlled studies indicate no benefit of these high levels. Feeding higher than recommended levels of dietary P has not improved either milk production or reproductive efficiency in controlled research studies. In line with this research, the most recent NRC (2001) recommends lower dietary P levels.

Phosphorus can be supplemented by adding monocalcium or dicalcium phosphate, monosodium phosphate, ammonium phosphate (high availability); steamed bone meal, defluorinated phosphate, sodium tripolyphosphate (medium availability); or low-fluorine rock phosphate, soft rock phosphate...
Phosphorus that is bound to phytate, so-called phytate-P, is not readily available to nonruminant animals such as swine. However, rumen microbes produce phytase, an enzyme that effectively releases P from phytate (Morse 1989). Phytate-P is readily available to ruminants such as dairy cattle. Over 99% of P bound to phytate is released from wheat middlings, hominy, soybean meal, corn distillers grains, and cottonseed meal during rumen fermentation of the feedstuff (Morse 1989). Therefore, do not over-supplement P above recommendations in a mistaken attempt to compensate for phytates in feeds.

Phosphorus is the most expensive nutrient in typical mineral-vitamin formulations for dairy cattle. For example, feeding a ration containing 0.45% P versus a diet containing 0.55% P would save about $0.05/cow daily. For 100 cows over a year’s time, it would save about $1,825.

Dry cows require only 0.25% P in the ration dry matter. A 1,300-pound milk cow, however, requires about 17 grams of P daily for maintenance plus 0.90 grams per every one pound of daily milk production. For example, a 1,300-pound cow producing 85 lbs of milk requires about 94 grams of P daily.

Signs of P deficiency include inactive ovaries and lack of estrus behavior (NRC 1989). Cows may eat wood or dirt or drink urine. Over-supplementation of P generally will not impair performance; the maximum tolerable level is 1.0% of the ration dry matter. However, dry cow health may be impaired when excessive P is fed during the dry period. Over-supplementation of P also leads to increased environmental risks due to excessive P content of the manure. Keep in mind that commonly fed commodity feeds and byproducts can vary substantially from source to source in content of nutrients including P and other minerals. When formulating diets containing byproduct feeds, it is important to test regularly for nutrient content and to adjust the ration accordingly. In some cases, using least-cost ingredients increases the diet’s P level over NRC (2001) recommendations. For example, a traditional diet containing alfalfa, corn silage, soybean meal, and corn would contain about 0.40% to 0.45% P. In contrast, a diet with 30% to 40% corn gluten feed, although costing less, would contain between 0.55% to 0.60% P. Dairy producers need to weigh the relative feed cost savings versus the potential cost of excess nutrient excretion.

Excretion estimates of P in Table 12-1 show that a dietary P content of 0.40%, 0.45%, or 0.60% results in estimated annual excretion of P of 40 to 46 to 69 pounds per cow. Clearly, a dairy producer has considerable control over mineral excretion in the manure by manipulating the amount of mineral in the feed.

Feeding adequate P is important for cow performance and health, but 0.40% to 0.45% of the dietary dry matter is near the optimal dietary content for lactating dairy cows. For a cow producing 100 to 120 lbs of milk daily, a diet containing 0.45% P meets the NRC (1989) recommendation. However, the same dietary P level provides about 140% of the daily P requirements for a cow producing only 40 to 50 lbs of milk.

From this observation, we can determine that the milking herd must be grouped by production level and that multiple rations must be formulated over the complete lactation cycle to minimize P excretion into the environment.
This is hardly an earth-shattering statement. Remember, the goal is to keep excretion of N, P, and K as low as possible while maintaining optimum dairy cow performance.

**Potassium Requirements, Sources, and Excretion in Dairy Cows**

The dairy cow’s minimum requirement for K is 0.90% to 1.0% of the ration dry matter (NRC 2001). The maximum tolerable level is about 3.0%. In the late 1970s, Michigan researchers (Bolenbaugh 1977) found that 1.2% K was associated with optimum feed intake, milk yield, and normal blood K levels. Because more K is lost through sweat and saliva, supplemental K can help to alleviate symptoms of heat stress. Research results have been variable, but increasing dietary K levels to 1.5% or 1.6% of ration dry matter during periods of heat stress may be beneficial to the cow (Beede et al. 1992).

Signs of K deficiency include poor response to heat stress, crampiness when rising from free stalls, poor growth in young animals, and drinking of urine. Excessive K intake can lead to udder edema in fresh cows, greater incidence of retained placenta, and greater risk of displaced abomasum (DA) (NRC 2001). High K rations may increase the need for magnesium (Mg) supplementation. In general, try to maintain a 4:1 ratio of K to Mg to avoid this problem. Also, when supplemental fat is fed to dairy cows, Mg content in the diet needs to be increased to 0.35% of ration dry matter to compensate for soap formation and fat excretion. Excessive K intake decreases Mg and increases urine output.

Potassium supplementation is seldom needed because most forages contain high concentrations of K. For example, in parts of the Midwestern United States, alfalfa routinely tests over 3.0% K on a dry matter basis. The NRC (1989) lists the K content of alfalfa at 2.2%, so relying on book values can result in substantial overfeeding of K. In some instances, however, high corn silage diets will need some K supplementation. Good sources of K include potassium chloride and commercial premixes.

High levels of dietary K during the dry period, especially during the last 2 to 3 weeks prepartum, can predispose the fresh cow to milk fever, DA, uterine problems, and other metabolic disorders. Try to keep K levels during the dry period to less than 0.65% to 0.70%. If the ration is high in K due to high forage K content, there is little the producer can do in the short term. The only long-term solution is to lower the K level in the forages. In the case of K, forages take up far more than needed for maximum dry matter yields per acre. Plant concentrations of 2.0% to 3.0% are adequate for plant growth, but 6.0% K in grass silage has been reported.

Excessive feeding of K puts substantially more K into the environment than necessary. As Table 12-2 shows, increasing the K content of the diet from 0.80% to 1.2% of the ration dry matter increases K output from 88 to 146 lbs/cow annually.

**Avoid salt over-supplementation**

When manure is applied, crops can use N, P, and K. Plants will increase K uptake to potentially undesirable concentrations for cattle; however, they use sodium (Na) and chloride (Cl) sparingly. Adding Na or Cl to diets or in

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Remember, the goal is to keep excretion of N, P, and K as low as possible while maintaining optimum dairy cow performance.

High levels of dietary K during the dry period, especially during the last 2 to 3 weeks prepartum, can predispose the fresh cow to milk fever, DA, uterine problems, and other metabolic disorders.

Excessive feeding of K puts substantially more K into the environment than necessary.
free-choice supplements might be detrimental to the long-term sustainability of farm land receiving manure (Meyer 2001). When total mixed rations are fed, salt does not need to be supplemented free choice. If a total mixed ration is not fed, salt should only be supplemented when adding minerals is beneficial to the animal’s productivity.

**Nitrogen Requirements, Feeding Strategies, and Excretion in Dairy Cows**

Table 12-2 illustrates the N excretion from two different diet formulation approaches. *Remember that CP is simply the N content multiplied by 6.25.* One diet is high in rumen degradable protein (RDP) and the other diet is lower in RDP, while meeting the overall protein requirement of the cow with higher levels of rumen undegradable protein (RUP, or “bypass” protein). High-producing dairy cows require a proper balance of RUP and RDP to meet their requirements for metabolizable protein (MP). Metabolizable protein is the protein that the cow actually absorbs and uses for production (NRC 2001). The requirement for RUP for lactating dairy cows is 35% to 38% of total CP. When cows were precisely fed to meet RUP and RDP requirements, they excreted 223 pounds of N per year. When cows were fed simply to meet their total CP requirement, however, they excreted 260 pounds of N per year (Table 12-2).

University of Nebraska research in the late 1990s (Grant and Haddad 1998) showed that cows produced the same amount of milk when fed a 17.5% CP diet that was balanced for RUP and RDP as when cows were fed a 19.5% CP diet not balanced for RUP and RDP. In this study, alfalfa was the sole forage and so overall dietary CP content was high. In practice, it is often desirable to feed a blend of legume/grass forages plus corn silage (or other grain silage) to better meet the cow’s requirements for CP, RUP, and RDP. So, as with P, considerable dietary control of nutrient excretion is possible. *A producer should always strive to formulate the lowest CP diet possible that also meets the cow’s requirements for degradable and undegradable protein (RDP, RUP).*

Recently, dairy heifers (570-1,080 lb body weight) were fed total mixed rations containing either 9.6% or 11.0% CP. Reducing N intake by 14% (9.6% vs. 11.0% CP) resulted in a decrease of 29.6%, 19.8%, and 7.4%, respectively, of urea-N, total N, and percentage N excreted in the urine. Ammonia volatilization was reduced in vitro by 28.1% (James et al. 1999).

The dairy cow excretes N via milk, urine, and manure. Milk N represents about 30% of total N intake, manure N from 30% to 40%, and urinary N about 20% to 40% of total N intake. In terms of amount of N excreted daily, urinary N appears to increase more than manure N with higher N intakes. Excessive intakes of dietary N can be monitored by either blood urea nitrogen (BUN) or by milk urea nitrogen (MUN). A BUN level in excess of 18 to 20 mg/dl or a MUN level in excess of 18 mg/dl can be associated with lower reproductive performance, higher feed costs, health problems, and poorer milk production. *A clear relationship between BUN or MUN values and conception rate does not presently exist, but high BUN or MUN values do indicate potential problems.*
Milk urea N analyses can be used as a signal, or “red flag,” to point out potential problems in your feeding program. In particular, high MUN values reflect excessive dietary CP or low rumen degradable nonfiber carbohydrates (NFC). The NFC fraction, usually composed of starch and other sugars, can be low when insufficient grain is fed or grain is improperly processed. Appropriate MUN testing over a period of several months to fine tune a feeding management program can result in
- Precisely meeting nutritional requirements.
- Lower feed costs.
- Increased reproductive performance.
- Increased milk protein yield.
- Minimal N excretion into the environment.

A high MUN (greater than 18 mg/dl) indicates
- Crude protein is too high and/or RDP is too high.
- Rumen fermentable NFC is too low, and/or protein and NFC are not properly combined in the diet.

A low MUN (less than 12 mg/dl) indicates
- Low CP in the rations.
- Improper mix of undegradable and degradable protein, and/or high rumen fermentable NFC.

In the future, MUN will be useful, allowing dairy producers to better manage their feeding programs and minimizing N excretion into the environment.

For more information on MUN testing and interpretation of results, consult *NebGuide G96-1298, Milk Urea Nitrogen Testing* available on the University of Nebraska website: [http://www.ianr.unl.edu/pubs/dairy](http://www.ianr.unl.edu/pubs/dairy).

Currently, MUN analyses are becoming the most widespread means of evaluating a ration’s CP or N content versus requirements and if CP is being under- or overfed versus NFCs.

Many dairy producers overfeed CP (i.e., N), which results in excessively high output of N in both urine and manure. Crude protein is often fed at levels to support 25,000 lbs of milk per cow or more annually, even when the herd’s actual milk production is substantially less. This practice is expensive and can also negatively affect the environment. The challenge to dairy producers, nutritionists, veterinarians, and other consultants is to formulate diets that meet the cow’s protein requirements but also minimize N excretion. Remember, milk yield does not need to be sacrificed to minimize N excretion into the environment.

The following feeding strategies provide ways to control N excretion:
- Increase dry matter intake
- Improve forage quality
- Consider forage protein fraction
- Consider feeding method
- Consider supplemental protein source

The first major goal is to minimize purchased feed N inputs; the second is to improve the dairy cow’s efficient use of N. The environmental importance of reducing purchased feed inputs for your dairy is discussed in detail in Lesson 2, Whole Farm Nutrient Planning.

Remember, milk yield does not need to be sacrificed to minimize N excretion into the environment.
**Increase dry matter intake**

The percentage of CP required in the ration to provide an absolute amount of protein to support milk production varies with intake level. A 5% increase in intake reduces the CP needed by about 1%. So, more CP could come from homegrown feeds, decreasing the amount of purchased feed required. Also, increasing intake level increases microbial protein synthesis in the rumen, which would decrease the need for higher dietary protein.

**Improve forage quality**

Higher quality legume/grass forage contains more protein, less fiber, and more energy, so it can provide more protein and dry matter to the ration, reducing reliance on purchased protein sources. When purchased N inputs are minimized, the degree of N introduced into the environment from sources outside the farm will be reduced. In general, providing energy from highly digestible, high-quality forages will maximize dairy cow performance and health.

**Consider forage protein fractions**

Supplement highly degradable forage protein (such as legume silage) with less degradable sources of protein (such as corn silage). Often, this will result in improved milk production at lower CP levels in the diet. Common and effective supplemental sources of RUP include blood meal and feather meal combinations, distillers grains, treated or heated soybeans and other oilseeds, and fish meal.

**Consider feeding method**

Method of feeding can alter N utilization. Feeding sequence, feeding frequency, and grouping strategy all influence how the cow uses dietary N. Synchronizing the delivery of RDP and rumen fermentable carbohydrate can increase the cow’s efficient use of N and decrease N excretion although the mechanism remains undetermined (NRC 2001). It is possible that synchronizing the digestion rates of protein and carbohydrate results in greater microbial protein production. Grouping is especially important to avoid over-supplementing N and other nutrients. A one-group total mixed ration may be easier to manage, but a multiple grouping approach better minimizes protein overfeeding, decreases N excretion, and lowers feed costs.

**Consider supplemental protein source**

Use protein supplements to allow the cow’s RDP and RUP requirements to be met without overfeeding CP. In the future, more emphasis will be placed on the amino acid content of various protein sources. Ultimately, an imbalance of amino acids available to the cow for digestion and metabolism will impair milk and milk protein production.

The primary objective of any dairy feeding program is to achieve profitable milk production. For many producers, this means high levels of milk production. The guidelines in this lesson show how high milk production can coexist with reduced excretion of manure nutrients. Keep in mind, however, that the percentage of nutrients needed for maintenance decreases as milk production increases.
Self-Assessment of Your Dairy’s Feeding Program

Appendix A provides you with a self-assessment of your dairy operation that summarizes the major points of this lesson. Consider each nutrition/management factor listed in the table and what effect that factor has on N or P excretion. If the effect listed is unclear to you, go back and review the appropriate part of the lesson. Then, consider two things:

1. Is each management option currently used on your operation to minimize nutrient excretion into the environment?
2. If it is not, is it a viable option for the future?

Thinking through this self-assessment will allow you to put together the best feeding program for your herd, optimizing performance and minimizing nutrient excretion.

The Bottom Line: Are High Milk Yield and Minimal Nutrient Excretion Mutually Exclusive?

The feeding strategies just presented in this lesson provide a starting point for formulating diets that minimize nutrient excretion into the environment but still meet the requirements for high levels of milk production. As computer programs become more sophisticated and our knowledge of cow nutrient requirements becomes more precise, we will be able to do a better job of feeding cows for high levels of performance without simply overfeeding major nutrients. Computer programs, such as the Cornell Net Carbohydrate and Protein Model®, Spartan Dairy Ration Evaluator®, the Ohio Dairy Ration Program®, and the latest Dairy NRC (2001) model are four examples of computer software that allow nutritionists to accurately formulate diets that meet, without exceeding, the cow’s nutrient requirements and provide nutrients in the proper ratios and amounts for the cow’s most efficient use. Other software packages are available that will accomplish the same objective.

So, the answer is, “No, high levels of dairy productivity and minimal N, P, and K excretion are not mutually exclusive.” A dairy producer can feed for high performance and still minimize any negative impact of nutrient excretion on the environment. Ensuring cow comfort, maximizing feed intake, testing all forages and major feed ingredients, properly formulating rations, using soil tests, and determining proper soil fertilization will all lead to a more environmentally sound feeding program. Properly formulated rations will not only support high production levels but will also minimize nutrient excretion into the environment.
APPENDIX A
Environmental Stewardship Assessment: Management of Dairy Feed Nutrients

For each issue listed in the left column of the worksheet, read across to the right and circle the statement that best describes conditions on your farm. If any categories do not apply, leave them blank.

<table>
<thead>
<tr>
<th>Practices in the low-risk category will produce the following environmental benefits according to the key below:</th>
</tr>
</thead>
<tbody>
<tr>
<td>N Reduced nitrogen excretion</td>
</tr>
<tr>
<td>P Reduced phosphorus excretion</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Issue</th>
<th>Low Risk (Risk 1)</th>
<th>Moderate to Low Risk (Risk 2)</th>
<th>High to Moderate Risk (Risk 3)</th>
<th>High Risk (Risk 4)</th>
<th>Environmental Benefit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dairy Cows</td>
<td>Nutrient concentration in diet</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>High-producing group</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>16% crude protein</td>
<td>17%</td>
<td>18%</td>
<td>19%</td>
<td>20%</td>
<td>N, NH\textsuperscript{3}, P, O</td>
</tr>
<tr>
<td>0.3% phosphorus</td>
<td>0.4%</td>
<td>0.5%</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Low-producing group</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>13% crude protein</td>
<td>14%</td>
<td>15%</td>
<td>16%</td>
<td>17%</td>
<td>N, NH\textsuperscript{3}, P, O</td>
</tr>
<tr>
<td>0.3% phosphorus</td>
<td>0.4%</td>
<td>0.5%</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Dry group</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>11% crude protein</td>
<td>12%</td>
<td>13%</td>
<td>14%</td>
<td>15%</td>
<td>N, NH\textsuperscript{3}, P, O</td>
</tr>
<tr>
<td>0.2% phosphorus</td>
<td>0.3%</td>
<td>0.4%</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Issue</th>
<th>Low Risk (Risk 1)</th>
<th>Moderate to Low Risk (Risk 2)</th>
<th>High to Moderate Risk (Risk 3)</th>
<th>High Risk (Risk 4)</th>
<th>Environmental Benefit</th>
</tr>
</thead>
<tbody>
<tr>
<td>What is the quality of the homegrown hay-crop forages?</td>
<td>More than two-thirds of haycrop produced have NDF levels: &lt; 60% (grass) &lt; 45% (legumes)</td>
<td>More than half of haycrop produced has NDF levels: &lt; 60% (grass) &lt; 45% (legumes)</td>
<td>More than half of haycrop produced has NDF levels: &gt; 60% (grass) &gt; 45% (legumes)</td>
<td>N, NH\textsuperscript{3}, P, O</td>
<td></td>
</tr>
<tr>
<td>How much homegrown forages are being fed? (Lactating dairy herds only: See last sheet for example calculations.)</td>
<td>Reliably measured by weighing amounts fed and feed refused, AND cattle are consuming appropriate amounts.</td>
<td>Reliably estimated by weighing amounts fed and estimating feed refused, AND cattle are consuming appropriate amounts.</td>
<td>Reliably estimated by weighing amounts fed and estimating feed refused, AND cattle are not consuming appropriate amounts.</td>
<td>Book values for dry matter intake are used to balance rations, AND amounts fed or refused are not weighed.</td>
<td>N, NH\textsuperscript{3}, P, O</td>
</tr>
<tr>
<td>How often is dry matter intake measured or estimated?</td>
<td>Weekly</td>
<td>Every 2 weeks</td>
<td>Monthly</td>
<td>Infrequently</td>
<td>N, NH\textsuperscript{3}, P, O</td>
</tr>
</tbody>
</table>

Adapted from the Guide to Agricultural Environmental Management in New York State 2001.
### APPENDIX A
Environmental Stewardship Assessment: Management of Dairy Feed Nutrients (continued)

<table>
<thead>
<tr>
<th>Issue</th>
<th>Low Risk (Risk 1)</th>
<th>Moderate to Low Risk (Risk 2)</th>
<th>High to Moderate Risk (Risk 3)</th>
<th>High Risk (Risk 4)</th>
<th>Environmental Benefit</th>
</tr>
</thead>
<tbody>
<tr>
<td>How often are feeds analyzed for nutrient and dry matter content?</td>
<td>Feeds are analyzed for nutrient content at least monthly, AND dry matter content of wet feeds is determined weekly on the farm.</td>
<td>Feeds are analyzed for nutrient content at least monthly, AND dry matter content of wet feeds is determined less than weekly on the farm.</td>
<td>Feeds are analyzed for nutrient content only when a new feed or forage crop is fed, OR on-farm forage dry matter determination of wet feeds is not practiced.</td>
<td>Feeds are not regularly analyzed.</td>
<td>N, NH&lt;sub&gt;3&lt;/sub&gt;, P, O</td>
</tr>
<tr>
<td>How often are rations balanced?</td>
<td>Rations are balanced more than six times a year, OR when changes in feed quality are anticipated.</td>
<td>Rations are balanced when a change in production or feed is noticed.</td>
<td></td>
<td>No systematic or regular ration balancing is practiced.</td>
<td>N, NH&lt;sub&gt;3&lt;/sub&gt;, P, O</td>
</tr>
<tr>
<td>How is protein balanced in rations?</td>
<td>Protein levels are fed at NRC recommendation, AND balanced for RDP and RUP fractions, AND a program that models rumen carbohydrate and protein interactions is used.</td>
<td>Protein levels fed at NRC recommendation, AND balanced for RDP and RUP fractions.</td>
<td>Protein levels fed at NRC recommendation.</td>
<td>Protein fed in excess of or below recommended levels, OR protein levels fed are not reliably known.</td>
<td>N, NH&lt;sub&gt;3&lt;/sub&gt;, O</td>
</tr>
<tr>
<td>How are P and K levels in rations determined?</td>
<td>P and K levels are fed at NRC recommendations, AND low K forages are fed to dry cows.</td>
<td>P and K levels are fed at NRC recommendations.</td>
<td>P and K fed in excess or below recommended levels.</td>
<td>P and K levels fed are not reliably known.</td>
<td>P</td>
</tr>
</tbody>
</table>

### Additional Information:

**Herd health and performance issues:**
- Is the herd on a regular health program with a local veterinarian?
- Is the incidence of calving difficulties or post-calving disorders (ketosis, milk fever, retained placenta, displaced abomasum, or mastitis) less than 5% in the herd?
- Are cattle growing and producing up to industry standards or producer's expectations?
- For milking cows, are adequate dry periods allowed? (First-calf heifers at least 55 days; older cows at least 45 days)
- Does the herd show signs of lameness, abnormal hoof growth, or other foot problems?
- Are animal beds/packs clean and dry with plenty of bedding?
- Do animals show signs of bruising of hocks, of thurls, or around shoulders or pinbones?
- Is there adequate watering and feeding space for animals?
- Are barns adequately ventilated with no detectable drafts or stale air?

**General nutrition and feeding issues:**
- Do high-producing dairy cows have access to feed at least 20 hours a day?
- Are feed bunks cleaned daily to avoid fouling of fresh feed?
- Is fresh, clean water readily available to animals?
- Is the herd adequately grouped and fed by production or nutritional needs?
- Is wet chemistry used to determine mineral analysis of feeds?
APPENDIX A
Environmental Stewardship Assessment: Management of Dairy Feed Nutrients (continued)

Calculating homegrown forage dry matter fed as a percent of average herd bodyweight

Information needed:
- Total amount of each forage fed to lactating herd (lbs Forₙ)
- Dry matter content of each forage fed (%DMₙ)
- Percentage estimate of annual needs of each forage produced on farm (%Homegrownₙ)
- Average herd bodyweight (Herd Bdwt)

Equation:

\[ \frac{\sum \left[ (\text{lbs Forₙ}) \times (%DMₙ) \times (%Homegrownₙ) \right]}{(\text{Herd Size} \times \text{Herd Bdwt})} \times 100\% \]

Where "n" defines each forage fed to the lactating herd.
If average herd bodyweight is unknown, use 1,400 for large Holstein, 1,300 for small Holstein, 1,200 for Guernsey and Brown Swiss, and 1,000 for Jersey herds.

Example: A 95-cow Holstein herd is grouped by production and fed forages according to the table below. The average herd bodyweight is 1,350 lbs.

<table>
<thead>
<tr>
<th>Feed</th>
<th>Pounds as Fed per Production Group</th>
<th>% dry matter</th>
<th>% homegrown</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>High group</td>
<td>Low group</td>
<td></td>
</tr>
<tr>
<td>Corn silage</td>
<td>2,150</td>
<td>2,350</td>
<td>34</td>
</tr>
<tr>
<td>Alfalfa haylage</td>
<td>1,185</td>
<td>975</td>
<td>41</td>
</tr>
<tr>
<td>Mixed grass hay</td>
<td>0</td>
<td>450</td>
<td>88</td>
</tr>
</tbody>
</table>

Homegrown forage dry matter fed as a percent of average herd bodyweight

- Corn silage: 
  \[ \frac{\left(2150 + 2350\right) \times 0.34 \times 1.00}{\left(95 \times 1350\right)} \times 100 = 1.19\% \]
- Alfalfa haylage: 
  \[ \frac{\left(1185 + 975\right) \times 0.41 \times 0.90}{\left(95 \times 1350\right)} \times 100 = 0.62\% \]
- Mixed grass hay: 
  \[ \frac{\left(0 + 450\right) \times 0.88 \times 0.70}{\left(95 \times 1350\right)} \times 100 = 0.21\% \]

Homegrown forage dry matter fed (percentage of herd bodyweight) 2.02%

This would be considered #2 level of potential concern for amount of homegrown forage feeding.

Note: Since a herd ration generally changes many times during the year, it is best to calculate this parameter periodically.
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References


Glossary

**Agronomic rate.** Applying sufficient nutrients for crop growth, without overapplying nutrients.

**Blood urea nitrogen (BUN).** Amount of urea present in the blood. Indicator of the efficiency of protein digestion in the rumen. Levels in excess of 18 to 20 mg/dl indicate a problem.

**Crude protein (CP).** Amount of nitrogen in a sample multiplied by 6.25 (assumes that protein is 16% nitrogen, 100/16 = 6.25).

**Degradable protein.** Fraction of dietary protein that is degraded in the rumen.

**Dietary dry matter.** Dry matter represents the moisture (water)-free nutrient composition of a feed.

**Digestibility.** Percentage of feed or a feed nutrient that is absorbed through the digestive tract. It can be calculated as [(lbs nutrient intake - lbs nutrient in feces) ÷ lbs nutrient intake] x 100%.

**Displaced abomasum (DA).** Metabolic disorder in dairy cows in which the abomasum (true stomach) moves (displaces) either to the left or right within the abdominal cavity. Major predisposing factors include inadequate dietary roughage and hypocalcemia.

**Dry matter content.** The portion of a feed remaining after all of the water is driven off. This portion contains all of the nutrients for which a ration is balanced. Also expressed as percent (%) dry matter.

**Dry matter intake.** Amount of feed dry matter content a cow will voluntarily eat in a day. The larger the dry matter intake, the lower the percentage of nutrients required to supply the daily requirements.

**Dry period.** Period of time in which a cow is not giving milk. Prior to calving, a mammary gland requires a rest period during which old lactating tissue is reabsorbed and new milk secreting tissue replaces it. Without the dry period, the gland will not produce to its potential.

**Forages.** Feed containing the vegetative parts of a plant. Haycrop forages (i.e., alfalfa hay or silage) do not contain any grains, while grain crop forages (i.e., corn silage) contain both vegetative and grain portions of the plant. Cattle feeds are generally classified into forages or concentrates (grains).

**Forage quality.** A qualitative measure of the forage’s nutritive value and digestibility. It is best quantified by measuring the feed’s structural fibers.

**Metabolizable protein (MP).** Protein that is actually absorbed and utilized by the cow for productive purposes. Composed of undegraded feed protein, microbial protein, and endogenous protein.
National Research Council (NRC). Scientific body that sets nutritional standards for feeding animals in the United States.

Neutral detergent fiber (NDF). In the laboratory, NDF is the residual left after a sample of feed is digested in a neutral detergent solution. It contains the structural fiber component (cellulose, hemicellulose, and lignin) of plant cell walls and is closely related to the amount of forage a cow will voluntarily eat.

Nonfiber carbohydrate (NFC). More rapidly degradable carbohydrate fraction that is composed of starch, sugars, and pectin.

Milk urea nitrogen (MUN). Similar to blood urea nitrogen. The amount of urea present in the milk is an indicator of the efficiency of protein use by the cow. Amounts in excess of 18 mg/dl signal a problem.

Phytates. Acids present in some feeds that bind minerals such as phosphorus, making them less available to nonruminant animals such as pigs. Ruminants possess a phytase enzyme in the rumen that can liberate the bound phosphorus.

Rumen degradable protein (RDP). Fraction of protein sources that supply peptides, amino acids, and ammonia for rumen microbial growth.

Rumen undegradable protein (RUP). Fraction of protein sources that essentially escape digestion in the rumen and deliver intact protein to the lower digestive tract.

Wet chemistry. Complete chemical analysis of feeds to quantify nutrients or minerals in feeds. Two methods of feed analysis are available from most labs: wet chemistry and near-infrared refractance. Wet chemistry is more accurate for mineral analysis of feeds.

Wet feeds. Forages, grains, or byproduct feeds generally with less than 87% dry matter whose moisture content can significantly vary over time or between batches (i.e., ensiled forages, high-moisture corn, wet brewer’s grains).

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