

HOW AGRONOMIC PRACTICES AFFECT MINERAL BALANCE FOR DAIRY COWS

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ABSTRACT

Alfalfa producers can help dairymen prevent milk fever and other periparturient diseases in dairy cattle by providing alfalfa hay low in potassium and sodium. They should be able to demand a premium for supplying hay to this niche market.

Key Words: alfalfa, dietary cation-anion difference, potassium, milk fever

INTRODUCTION

Veterinarians and nutritionist know the importance of balancing dairy rations for minerals. The relationship between many of these minerals is complex. For example, an excess of molybdenum or sulfate in forages may lead to a deficiency of copper or selenium by inhibiting absorption (NRC 1989). Some minerals act together to affect certain physiological parameters. For example, cations add together to cause a metabolic alkalosis while anions add together to cause a metabolic acidosis. This is known as cation-anion difference (DCAD). This paper will acquaint alfalfa producers with the concept of DCAD and its effect on cow health. Alfalfa producers can help prevent milk fever by providing hay low in potassium (K) and sodium (Na) and high in chloride (Cl) and sulfur (S).

DCAD AND MILK FEVER PREVENTION

Veterinarians and nutritionists now prevent milk fever by balancing rations for dietary cation-anion difference (DCAD) (Beede, 1992; Goff, 1992). An over-simplification of the DCAD concept is that cations (sodium and potassium) are bad because they cause a slight metabolic alkalosis which leads to milk fever—Anions (chloride and sulfur as sulfate) are good because they cause a slight metabolic acidosis which prevents milk fever. These anions are frequently added to the ration in the form of anionic salts. The acidosis probably prevents milk fever because PTH receptors are more active in a slightly acidic environment (Goff, 1992).

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Several equations have been proposed for DCAD. The most popular equation is shown below. Other more complex equations take into consideration the effect of calcium, magnesium, and phosphorus.

$$(\text{Na}^+ + \text{K}^+) - (\text{Cl}^- + \text{S}^{2-}) = \text{DCAD in meq/kg DM}$$

Table 1. Conversion Factors for Ions.

Element	Atomic Weight	Equivalent Weight	meq/kg DM Factor
Na ⁺	23.0	23.00	435
K ⁺	39.1	39.10	256
Cl ⁻	35.5	35.50	282
S ²⁻	32.1	16.05	624

Using the above equation and the conversions in Table 1, the DCAD of an alfalfa sample can be calculated.

Example 1: An alfalfa hay tests at 4.00% potassium, 0.30 % sodium, 0.70% chloride, and 0.30% sulfur. What is the DCAD of the hay? This hay is a poor choice for close-up cows. A large amount of chloride and sulfate is needed to counteract the high cation concentration.

$$3.00 * 256 + 0.30 * 435 - 0.70 * 282 - 0.30 * 624 = 514 \text{ meq/kg DM}$$

Example 2: An alfalfa hay tests at 2.00% potassium, 0.30% sodium, 0.70% chloride, and 0.30% sulfur. What is the DCAD of the hay? This hay is a good choice for close-up cows.

$$2.00 * 256 + 0.30 * 435 - 0.70 * 282 - 0.30 * 624 = 258 \text{ meq/kg DM}$$

The optimum level of calcium for close-up cows is controversial. Some researchers believe calcium level has little to do with milk fever—That potassium is and always was the big culprit (Beede, 1992). However, the research is very convincing that feeding less than 20 grams of calcium per cow per day prevents milk fever (Green et al, 1981). In my opinion, both leading theories on preventing milk fever (low calcium and DCAD) are valid but should not be mixed. Low DCAD diets should not be low in calcium! Calcium flux through the body is increased with low DCAD diets and low calcium diets may cause serious calcium depletion and even cause milk fever. But just how high should calcium be? Most authors have suggested levels greater than 150 grams per head per day or about 1.2 per cent of the ration DM. Calcium is a double-edged sword. On one hand, it needs to be high to supply the calcium the body needs. On the other hand it is a cation and contributes to the metabolic alkalosis that leads to milk fever. At very high levels (2% of DM) calcium can contribute to the metabolic alkalosis and inhibit dry matter intake. I believe that when balancing for DCAD modest levels (1.0 to 1.2 % of the ration DM) of calcium are appropriate.

Phosphorus is another double-edged sword. It is an ion and thus causes acidification of the blood but at high levels it inhibits the conversion of vitamin D to the active hormone in the kidney. Sanchez was able to acidify the blood with phosphoric acid, but lowered calcium levels (Crill, 1996). The phosphorus level should meet NRC requirements (about 27 grams per head per day) but not be over 50 grams per head per day. This low level of phosphorus in combination with a high level of calcium leads to a high Ca:P ratio. This is OK. Attempts to narrow the Ca:P ratio by increasing phosphorus may cause milk fever.

Magnesium levels should be about 0.4% of the diet. It is especially important to have fairly high magnesium levels if the potassium level is high. Magnesium is another potential double-edged sword. A certain level is needed but too much of this low equivalent weight (and thus high equivalents per gram) element can contribute to metabolic alkalosis.

The most common anionic salts are calcium sulfate (gypsum), calcium chloride, magnesium sulfate (Epsom salts), magnesium chloride, ammonium chloride, and ammonium sulfate. The biggest disadvantages of using anionic salts to prevent milk fever are the extra costs involved and decreased dry matter intake—Anionic salts are unpalatable. Decreased dry matter intake resulting in prepartum weight loss predisposes cows to periparturient diseases like retained placenta, fatty liver, ketosis, and displaced abomasum (Bertics, 1992; and Dyk, 1995). The following scheme is frequently used to formulate diets using the DCAD concept (Beede, 1992; Goff, 1992):

- 1: Have all the potential close-up dry cow feeds tested for sodium, potassium, magnesium, calcium, chloride, sulfur, phosphorus, and of course energy, protein, and fiber.
- 2: Balance the ration for protein, energy, and fiber, using feeds low in potassium, sodium, and phosphorus, and high in calcium, chloride, and sulfur. The DCAD before adding anionic salts should be less than 200 meq/kg DM.
- 3: Add a combination of anionic salts until the ration dry matter contains 1.0 to 1.2% calcium, 0.4% magnesium, 0.25 to 0.35% phosphorus, and 0.4% sulfur. The DCAD should be about -150 to -100 meq/kg DM.
- 4: Monitor effectiveness with milk fever incidence and urine pH (Jardon 1995).

HOW ALFALFA PRODUCERS CAN HELP

Above, in step # 2 feeds low in potassium, sodium, and phosphorus are selected. Alfalfa with low potassium and sodium content is very helpful in formulating rations for close-up cows because less anionic salts need to be added. This is desirable not only because it saves money, but also because dry matter intake may be increased. The money saved from using less anionic salts is fairly easy to estimate. The money saved by increasing dry matter intake and thus decreasing metabolic disease is difficult to estimate but is probably greater than that saved by purchasing less anionic salts.

Using the two hay samples in example 1 and 2 let's compare the savings in anionic salt usage. We will assume the hays are identical in all other ways (protein, fiber, TDN, etc.) and that alfalfa is fed at 10 lb. (4.54 kg) DM per cow per day. The cost per equivalent of anionic salts is typically about 4 cents per equivalent.

$$514 - 258 = 256 \text{ meq/kg difference in DCAD}$$

$$256 \text{ meq/kg} * 4.54 \text{ kg} = 1,162 \text{ meq or } 1.16 \text{ equivalents less anionic salts needed.}$$

$$\text{Savings on anionic salts: } \$0.04 * 1.16 = 4.64 \text{ cents per cow per day}$$

The added value of the hay is \$9.28/ton of DM or about \$8.50 per ton as fed based on anionic salt savings alone. Again, the benefit from increased dry matter intake is probably at least this great.

Forages for close-up dry cows should be of high quality with respect to palatability, fiber, energy and protein. The energy and protein needs of these cows are increasing as the cows go through a natural peripartum decrease in dry matter intake.

Reducing the potassium level in alfalfa can be difficult. Low potassium soil increases winterkill of alfalfa and gives a competitive advantage to grasses over alfalfa leading to grassy alfalfa. All plants must have access to a certain amount of potassium to obtain maximal growth, but alfalfa, other legumes, and some grasses accumulate potassium within their tissues to concentrations well above those required for optimal growth of the plant if soil potassium is high (Goff, 1997). Optimal growth of alfalfa occurs with plant potassium concentration of 1.7 to 2.0%. Protein is maximized at 2.0 to 2.4% (Thomas, 1997B). Alfalfa often contains much higher levels. It is unlikely that any benefit is seen by increasing plant potassium beyond 2.5%. Current agronomic practices encourage over-fertilization with potassium (both commercial fertilizers and cow manure) resulting in luxury consumption of potassium by plants.

Warm season grasses (corn, switchgrass, big bluestem, and indiangrass) tend to be lower in potassium than cool season grasses (bluegrass, orchardgrass, and brome), but with the exception of corn, tend to be lower in protein and digestibility. Grasses have a fibrous root system, which makes them very efficient utilizers of soil potassium. Are there differences between species in potassium level? Work done at the Miner Institute in New York by Everet Thomas comparing three cool season grasses suggests there is (Thomas, 1996). Timothy is lower in potassium than reed canary grass, which is lower in potassium than orchardgrass. Work is under way to determine if there are differences in potassium uptake between varieties within a species. Work is also being completed on the effect of unusual fertilizers (ammonium sulfate, magnesium chloride, calcium chloride, etc.) on DCAD (Thomas, 1997A and 1997B). These fertilizers show promise not only in decreasing potassium and sodium levels but also in increasing forage sulfur and chloride levels. This is like putting the anionic salt right into the forage.

Recent studies in Iowa suggest differences in DCAD among different alfalfa cultivars (Horst 1997). These workers also showed wet seasons increase potassium uptake. Leaves contain more potassium than stems. The apical meristem (rapidly growing portion of the plant) contains a very high potassium level. As the plant matures the proportion of the plant that is apical meristem decreases, thus more mature plants are lower in potassium although the percentage of leaves may decrease. Later cuttings have lower potassium levels than early cuttings.

SUMMARY

I suggest alfalfa producers try to find a combination of alfalfa variety, fertilizer, cutting, irrigation level, etc. that yields a high quality low DCAD forage for close-up dry cows. Producers should be able to demand a premium for this niche market. I believe many producers would be willing to pay \$25 more per ton for hay that has been identified, tested, and guaranteed to have a low DCAD. There are probably some fields out there that are "accidentally" low in DCAD. They just need to be identified. Some forage laboratories have reasonably priced special DCAD packages that can be used to screen fields.

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