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Mineral Supplementation in the Grazing Cow Herd

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Introduction

Pasture forage is the most significant contributor to the trace mineral nutrition of grazing beef cattle. Mineral supplementation in beef cattle can be divided into two broad categories, macro-minerals and micro-minerals. These categories are based on the amount of mineral required in the cow's diet. As a rule of thumb, micro-minerals are required in amounts less than 1 gram per day compared to macro-minerals, which are often required at levels greater than 1 gram per head per day. Multiple trace minerals are essential for basic physiological functions in beef cattle. The table below illustrates the minerals that are recognized as essential to grazing cattle.

Table 1. Mineral Requirements of Beef Cows[1]

Macro-minerals, %[3]	Gestation	Lactation	Micro-minerals, ppm[3]	
Potassium (K)	0.60	0.70	Copper (Cu)	10.00
Magnesium (Mg)	0.12	0.20	Iron (Fe)	50.00
Sodium (Na)	0.06 – 0.08	0.10	Manganese (Mn)	40.00
Sulfur (S)	0.15	0.15	Zinc (Zn)	30.00
Phosphorus (P)	16 – 33 g / d[2]		Cobalt (Co)	0.10
Calcium (Ca)	13 – 24 g / d[2]		Iodine (I)	0.50
			Selenium (Se)	0.10

[1]Data taken from Nutrient Requirements of Beef Cattle, National Research Council, 1996.
[2]Dietary requirements vary by stage of production, with the highest requirement during the first 3 months post-calving.
[3]Macro-mineral requirements listed as % of total diet on a dry matter basis. Micro-minerals listed as ppm, or mg per kg of diet on a dry matter basis.

Table 2. Average Mineral Concentration of South Florida Bahiagrass[a]

Macro-minerals	Concentration, %	Micro-minerals	Concentration, ppm
Calcium	0.43	Copper	6.4
Phosphorus	0.27	Zinc	51.4
Potassium	0.74	Manganese	54.8
Magnesium	0.33	Iron	77.4

[a]Samples collected from 9 counties in south Florida. Samples collected monthly from March to December. Pastures fertilized in March (60 lb nitrogen/acre).

I. Review of Individual Trace Nutrients Essential to Grazing Beef Cattle

Copper

Copper is one of the most common trace nutrient deficiencies in grazing cattle. Copper is an important cofactor in approximately 30 enzyme systems. Deficiencies occur through the prolonged consumption of forages low in copper and/or the consumption of forages containing elevated concentrations of the natural copper antagonist, molybdenum. As well, dietary sulfur is an important catalyst in the copper / molybdenum interaction. Dietary sulfur levels greater than 0.35 % are often considered suspect in their potential for initiating copper deficiency. Blood copper concentrations are elevated during instances of stress, suggesting that stressed cattle may have a higher copper requirement. Copper should be supplemented using copper sulfate. Copper oxide is poorly absorbed and should not be used in cattle supplements. Some signs of copper deficiency include, (1) immune suppression (failure to respond to vaccination), (2) rough, dull hair coat, and (3) anemia

Zinc

Like copper, zinc is also an important cofactor in many enzyme systems. In ruminant diets, zinc deficiency has been shown to be an important contributor to male fertility. As well, diets fortified with adequate available zinc have been shown to improve hoof structural soundness in beef heifers. Copper and zinc are absorbed through similar pathways indicating a competition for absorption sites. Therefore, mineral supplements should be formulated with a copper: zinc ratio of around 1:2 or 1:3. Zinc should be supplemented using zinc sulfate. Some signs of zinc deficiency include, (1) connective tissue degeneration (hoof integrity), (2) bull reproductive failure (especially young developing bulls), and (3) anorexia and weight loss (notably in calves)

Selenium

The potential of selenium deficiency has been widely recognized throughout the US. Unlike most other essential trace nutrients, selenium supplementation offers a narrow range between deficiency and toxicity. In fact, many regions in the US are concerned with selenium toxicity in pasture forages. Selenium is essential for the maintenance of tissue integrity. Widely recognized deficiency symptoms include the degeneration of tissue resulting in a condition referred to as "white muscle disease". Selenium supplementation is commonly addressed via the inclusion of sodium selenite. Selenium inclusion is federally regulated at a maximum inclusion level not to exceed 3 mg/d. Nevertheless, if adequate mineral intake is achieved, selenium deficiency is rarely a problem when adequately supplemented via sodium selenite.

Some signs of selenium deficiency include, (1) muscle degeneration (white muscle disease), (2) reproductive failure, and (3) immune suppression.

Manganese

Manganese has been shown to be an important trace nutrient for proper bone formation in young animals and optimization of fertility in female cattle. Although dietary manganese absorption and retention in cattle is low, manganese deficiency in grazing cattle is uncommon. Considering the importance of manganese on cow fertility and young calf development, it is important to focus on optimal manganese nutrition prior to and following calving. Manganese sulfate is the most available form of manganese, but it is often difficult to find commercially. As an alternative, manganese oxide is an acceptable and widely used source of manganese supplementation. Some signs of manganese deficiency include, (1) bone abnormalities, (2) reduced growth rate, and (3) reduced fertility.

Iodine

Iodine is critical for the maintenance of proper thyroid function. This occurs through the essential role of iodine in the regulation and synthesis of thyroid hormone production. The influence of thyroid hormones affects nearly every physiological process in mammals. Ethylenediamine dihydroiodide (EDDI), often provided in trace mineral supplements as a foot rot preventative, provides a quality source of available iodine. As well, the inclusion of iodized salt in the base mineral mix may provide adequate iodine supplementation in most cases. Some signs of iodine deficiency include, (1) reduced fertility, (2) enlarged thyroid (goiter), and (3) stillborn, weak, and/or hairless calves.

Iron

Iron deficiency is seldom a problem in cattle consuming forages. In contrast, the antagonistic impact of dietary iron on copper absorption is often more important when attempting to balance trace mineral nutrients. Further, many ingredient sources of other trace nutrients are naturally contaminated with iron. Taken together, additional supplementation of iron to grazing cattle is probably not a concern. Iron deficiency is occasionally an issue in young calves or in adult cattle suffering blood loss usually as a result of parasite infestation. Iron is provided in most all trace mineral supplements in the form of iron oxide. This inclusion is provided only as a coloring agent, providing the classic dark red appearance of trace minerals. Iron oxide is basically *unavailable* to the animal. If supplemental iron is needed iron sulfate should be considered. Some signs of iron deficiency include, (1) anemia, (2) immune suppression, and (3) decreased calf weight gain.

Cobalt

Cobalt is essential to ruminants through its participation in the ruminal synthesis of vitamin B12. This metabolic process, unique to ruminants, allows us to virtually ignore the dietary supplementation of B-vitamins in cattle. In fact, since cobalt is poorly stored in body tissues, cobalt status in ruminants is commonly assessed via measurements of blood vitamin B12 concentrations. Multiple cobalt sources are utilized in mineral formulations, including carbonate, chloride, and sulfate. Some signs of cobalt deficiency include, (1) loss of appetite leading to weight loss, (2) listlessness and diarrhea, and (3) anemia.

Clearly, many trace mineral deficiency symptoms overlap. This is best explained by the intricate interrelationships shared between many of the essential trace minerals. High levels of one element may induce a deficiency in another. Therefore it is essential that formulations take into account the impact of one nutrient upon another. To further complicate the issue, clinical signs of trace mineral deficiencies are often not observed until the animal has achieved an acute deficiency state. Chronic trace mineral deficiencies may impact production parameters for many years without revealing themselves through classic clinical symptoms.

II. Antagonistic Minerals

Common antagonists of minerals found in forages include, 1) sulfur, 2) molybdenum, 3) iron, and 4) aluminum. Although deficiencies due simply to insufficient mineral intake exist, many minerals, such as copper, zinc, and selenium, may experience impeded absorption due to the influencing factors of other antagonizing elements. One well-known example is the antagonistic combination of copper and molybdenum. Molybdenum tends to accumulate in plants grown in poorer drained soils. As well, high pH soils are more likely to accumulate molybdenum. For many years, Florida's Okeechobee basin has been recognized for its ability to produce forages with high molybdenum.

In the rumen, sulfur and molybdenum combine to form a thiomolybdate complex. Thiomolybdates are able to irreversibly bind copper, rendering it unavailable for absorption. For molybdenum to exert an influence on copper, it is essential that an adequate level of dietary sulfur be available. When total dietary sulfur levels fall below 0.25%, even high levels of molybdenum seldom pose a problem with copper absorption. A common rule-of-thumb is if copper: molybdenum ratios are less than 4.5 to 1 and total dietary sulfur is greater than 0.25% then a potential molybdenum induced copper deficiency is likely. Along with molybdenum another antagonist of copper is iron. The contribution of multiple interfering compounds makes a clear understanding of trace mineral metabolism difficult. Many research groups, ours included, continue to focus efforts toward a better understanding of the intricate relationship of trace mineral nutrition in beef cattle production systems.

Antagonists in Fertilizer

Recently, we have identified certain fertilization practices that might impact the mineral status of grazing cattle. Ammonium sulfate is commonly used as a nitrogen source for bahiagrass pastures. Some studies indicate that bahiagrass yield may be improved by application of sulfur. In a recent study, we investigated the effect of ammonium sulfate versus ammonium nitrate on forage mineral accumulation and mineral status of grazing cows. These results showed that ammonium sulfate fertilization results in significant accumulation of forage sulfur (Table 3), which may contribute to impaired copper metabolism in cattle grazing these forages (Table 4).

Table 3. Effect of N fertilizer source on bahiagrass nutritive value

Item	Year	AS	AN	C	Pooled SEM[c]	AS & AN vs. C	AS vs. AN
		----------	%	----------		---------- (P =)	----------
IVOMD	1999	45.7	44.5	42.5	0.97	0.003	0.216
	2000	50.9	50.5	46.5	0.46	< 0.001	0.582
Sulfur	1999	0.48	0.17	0.19	0.28	< 0.001	< 0.001
	2000	0.51	0.22	0.25	0.02	< 0.001	< 0.001
Nitrogen	1999	1.82	1.88	1.81	0.10	0.883	0.623
	2000	1.88	1.94	1.65	0.05	<0.001	0.084

[a]Four observations/pasture were obtained by the collection of whole plants in randomly distributed grazing exclusion cages on each of four and five 28-d intervals in 1999 and 2000, respectively. Treatments consisted of 60 lb of N/acre from ammonium sulfate (AS) or ammonium nitrate (AN). An unfertilized control (C) was also used.
[c]Pooled standard error of the mean.

Table 4. Effect of N fertilizer source on liver trace mineral concentrations of grazing cows [a]

Item	AS	AN	C	Pooled SEM[b]	AS & AN vs. C	AS vs. AN
	----------	ppm	----------		---------- (P =)	----------
Cu	72	137	204	12.5	0.079	0.010
Fe	332	308	438	63.1	0.781	0.148
Mn	9.1	9.0	9.9	1.4	0.977	0.532
Mo	4.3	5.5	6.2	0.8	0.002	0.001
Zn	119	111	126	7.7	0.648	0.428

[a] Treatments consisted of 60 lb of N/acre from ammonium sulfate (AS) or ammonium nitrate (AN). An unfertilized control (C) was also used. Final Samples collected from 12 cows (2/pasture) at the end of the grazing period; year 2000. Initial liver mineral concentrations obtained from 12 random cows at the start of the grazing study were 372 ± 24, 14.7 ± 1.4, 2.6 ± 0.1, and 124 ± 3.7 ppm for Cu, Fe, Mn, Mo, and Zn, respectively.
[b]Pooled standard error of the mean.

The decision to apply ammonium sulfate to bahiagrass pasture should be based on plant sulfur need and cost compared to other nitrogen sources. Ammonium sulfate may improve bahiagrass yield when initial plant sulfur concentrations are below 0.20%. Application of ammonium sulfate will increase forage sulfur concentration, which may decrease cow response to copper supplementation. This situation will be most pronounced in regions where animals are prone to copper deficiency. Decisions to use ammonium sulfate, as a source of nitrogen fertilizer for bahiagrass should weigh the economic benefits of a potential yield response with the potential impacts on animal health associated with sulfur-induced copper deficiency.

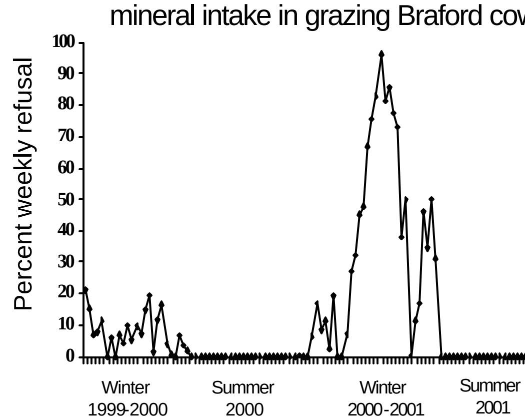
III. Trace Mineral Supplementation

Supplementation of trace minerals may occur through a variety of means, including free-choice loose mineral mixes, trace mineral blocks, and fortified energy and/or protein supplements.

A. Free-Choice Loose Mineral Supplements

This form of mineral supplementation is by far the most common supplementation strategy in grazing beef herds. In nearly all cases, it is an effective, cost-efficient means of delivering adequate mineral supplementation. Although formulations vary greatly, the common base mix should contain approximately 20 to 25% salt, along with 8 to 12% phosphorus. This variation in phosphorus content typically provides the most significant influence on overall mix cost. Intake is often targeted at two to four ounces per head per day. Unfortunately, achieving this target intake by all animals does not occur. Several animals within a herd will consume very little to no mineral at all. However, on the average, mineral consumption usually meets the desired intake levels. It is this averaging effect, over time, which allows free-choice mineral supplements to be the most practical choice for most cattlemen. Seasonal variation is evident. During the wetter summer months, cattle readily consume salt-based mineral supplements. In contrast, during the dryer winter months free-choice intake may be reduced by 15% or more. Weekly evaluation of mineral intake at the Range Cattle REC is shown in Figure 1. To avoid over consumption in the summer, offer mineral every 10 to 14 days at a level slightly exceeding the target intake. It is acceptable for the feeder to remain empty for a few

Figure 1. Effect of season on free-choice mineral intake in grazing Braford cows



days prior to the next scheduled day of mineral offer. In the winter when consumption is often reduced, try blending your mineral with your winter supplement (described below). If you do not utilize winter supplements try mixing your salt-based loose mineral mix with cottonseed meal or soy hulls at a 1 to 1 ratio. Remember to double your offer and monitor intake. An increase or decrease in this ratio may be used to control intake to your desired level.

B. Trace Mineral Blocks

In most grazing situations, trace mineral containing salt blocks cannot provide sufficient trace mineral intake to meet nutritional needs. Formulated as a hard, salt-based block, cattle are often unable to consume enough product to achieve their necessary level of trace mineral supplementation. Nevertheless, some grazing situations dictate the need for this type of supplementation. When cattlemen are physically unable to provide loose mineral or fortified supplements on a regular basis, trace mineral fortified salt blocks provide an opportunity to offer long-term mineral supplementation, therefore lessening the potential for trace mineral deficiency.

C. Fortified Energy / Protein Supplements

One of the most effective management strategies for addressing the trace mineral nutrition of beef cows involves the mineral fortification of energy and/or protein supplements. This is a simple approach, which ensures that trace mineral is offered to all animals on a regular basis. This may be achieved by fortifying traditional supplements with your current free-choice trace mineral supplement. Some producers simply fortify their winter supplement and return cows to free-choice product during months when supplement is not offered. This strategy is effective in decreasing the variability in free-choice trace mineral intake and in bolstering trace mineral tissue stores during the winter supplementation period. As well, mineral-fortified energy or protein supplements lessen the concern of reduced free-choice, salt-based mineral intake during the winter.

When supplementing trace minerals it is important to realize that cattle ***do not*** have the nutritional wisdom to consume trace minerals as needed. We have all heard the statements, “My cattle are not consuming mineral, so they must not need it” or, “My cows are eating four times their normal level, I guess they really need it”. Cattle only possess the ability to consume salt at the level of their requirement. Consequently, by altering the salt inclusion in mineral mixes, we can both encourage and discourage mineral intake. Remember that the majority of trace mineral intake beyond that nutritionally required by the animal is excreted in urine and feces. Over consumption of trace mineral may be an important inefficiency in beef cattle production systems. When cattle are over-consuming mineral, consider adding stock salt directly into the trace mineral mixture. Once mineral intake has normalized, remove the additional salt. *Do* *not provide stock salt and trace mineral supplement separately.* Because cattle are attracted only to salt, this strategy will decrease trace mineral intake and may lead to a deficiency state.

IV. Analysis of Herd Trace Mineral Status

If a trace mineral deficiency is suspected, a producer may wish to conduct an evaluation of herd trace mineral status. With today's technologies, this task is fairly simple and cost efficient. The following steps should be considered with attempting to evaluate herd trace mineral status and effectiveness of the trace mineral supplementation program.

A. Rule out other influential factors

The first step in identifying trace mineral deficiencies is to attempt to rule out other more directly contributing factors. For instance, if average cow body condition score is less than 4 ½, chances are far greater that decreases in reproductive performance and/or immune function are a result of energy deficiency versus trace mineral deficiency. Also, be sure to evaluate the basics of your current supplementation program. Does the product provide a balanced mineral profile using quality ingredients? Are the cattle being provided with a consistent supply of fresh, dry mineral? Are the cattle consuming the mineral at an appropriate level?

B. Forage trace mineral concentrations

Grazing cattle selectively consume forage with 25 to 30 % more crude protein than hand-clippings of the same pasture. In a field study, we attempted to collect the same forage being consumed by grazing steers. Prior to grazing controlled areas, we emptied the ruminal contents from four rumen-cannulated steers. During the grazing periods, we attempted to clip that forage which the steers were consuming. Later, the rumen of each animal was again emptied and the consumed forage rinsed with water. Even though we attempted to clip exactly the forage being consumed, the steers selected forage higher in crude protein (30.0%), calcium (52.6%), and phosphorus (36.8%), compared to hand-clipped samples. However, no differences occurred in the trace mineral content of steer selected vs. clipped forage (Table 5), suggesting that hand-clipped forage samples are a good reflection of the trace mineral concentration of animal-selected forage.

Table 5. A Comparison of the Trace Mineral Content of Hand-Clipped vs. Grazed Forage Samples[a]

Collection Method	Iron	Copper	Zinc	Manganese
Steer selection	152.7	10.7	20.4	11.3
Hand-clipped	154.8	11.5	19.5	12.8

[a]Results are expressed as the mean mineral content of triplicate analyses; all results are expressed as mg/kg DM.

When collecting forage samples for trace mineral analysis it is important to collect the sample from areas where animals are grazing (selecting). Do not collect from non-selected forage areas and be careful to not contaminate your sample with weeds or dirt. Prior to collection, find a laboratory that will test forage for trace mineral levels. Many commercial laboratories offer an analysis package containing a group of trace minerals for $15 to $30 per sample. The laboratory will provide directions for collection, handling, and shipping. It is important to test for copper, zinc, selenium, cobalt, and manganese. It is also important to consider including antagonistic trace minerals, which may interfere with the normal absorption of other minerals. Three commonly recognized antagonists in forages are molybdenum, iron, and sulfur.

C. Herd trace mineral status

Often, it is possible to establish a reasonable plan of action by addressing points 1 and 2. However, in some instances it may be important to further explore a potential trace mineral deficiency by examining animal blood and/or liver mineral status. For two of the most commonly deficient trace minerals, copper and selenium, liver samples provide the most reliable indicator of actual animal stores. Blood samples are an unreliable approach for the measurement of these elements unless the cattle are severely deficient. Modern laboratory technology allows for the use of very small tissue samples for the analysis of multiple trace elements. Today's liver biopsy collection technique is simple, inferring very little stress to the animal.