Developing a mineral program: combining the art and the science

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Historically, cattle producers believed that cattle contained "nutritional wisdom" meaning that they would consume anything such as dirt, bones, and wood in order to meet the body's nutrient requirements. However, cattle do not intuitively know when they need a specific nutrient to meet requirements for optimal performance (i.e. treat their own subclinical deficiencies). They do appear, however, to have nutrient seeking behavior when extremely (clinically) deficient in some minerals (such as phosphorus). Subclinical mineral deficiencies are much more common than clinical deficiencies and have been linked to decreased calf growth, calf immunity, and impaired reproductive performance.

On the surface, planning a mineral supplementation program seems simple. Evaluate the mineral requirements of the animal and compare it to the intake of mineral. Then, supplement what does not meet the requirement. Unfortunately, minerals interact with each other and other components of the diet, making mineral nutrition complex and precision supplementation virtually impossible, especially in grazing situations where determining the mineral intake and providing supplemental mineral are in and of themselves challenging. Those mineral elements

Table 1. Average Mineral Composition of Subirrigated Meadow Hay, from Gudmundsen Sandhills Laboratory, 1999-2015.

Mineral	June Harvest	July Harvest	Oct. 1st Regrowth	Mineral Requirement[1]
	Macro Mineral, %			
Calcium	0.37	0.63	1.09	0.16 - 0.40
Phosphorus	0.18	0.13	0.17	0.13 - 0.23
Potassium	2.39	1.84	1.76	0.60 - 0.70
Sulfur	0.18	0.17	0.25	0.15
Magnesium	0.20	0.19	0.24	0.12 - 0.20
Sodium	0.09	0.06	0.08	0.07 - 0.10
	Trace Mineral, ppm			
Iron	111	85	114	50
Manganese	33	35	37	40
Zinc	17	13	16	30
Copper	6	5	6	10

which have a reasonably likelihood of being deficient in forage based diets are the macro minerals: calcium, phosphorus, sodium, and magnesium and the trace minerals: manganese, zinc, cobalt, copper, iodine, and selenium. Deficiencies typically arise in two ways: primary deficiencies occur when dietary intake of minerals does not meet the requirements of the animal and secondary deficiencies which occur when antagonisms reduce the availability of the mineral to the animal. Additionally, mineral sources differ in bioavailability as not all mineral sources are absorbed to the same extent.

This means that each mineral in the diet must be evaluated for amount, bioavailability of the source (amount that will be absorbed by the animal and thus available for use by the animal), and possible interactions with other minerals. Otherwise we can create a completely new problem when changing a mineral program to fix an existing problem. These factors make formulation of mineral supplements seem more akin to an art than a science. However, there are some common guidelines that can be useful for developing an effective mineral supplementation program.

An example of forage analysis of meadow hay from the Nebraska Sandhills is shown in Table 1. Mineral content of forage is variable and will vary even within a geographical location due to plant species, stage of plant maturity, soil characteristics (including soil pH) and climatic conditions. Although there is much variability in the mineral content of forages there are some generalizations that can be made. [1] Dry beef cow requirement is the lower number and lactating cow is the higher number.

Macro-mineral content of forages

Based on the samples from Nebraska, Colorado, Wyoming, South and North Dakota, mineral requirements for potassium and sulfur are almost always met and do not need to be supplemented. Calcium requirements are often met. However, calcium supplementation may sometimes be needed when feeding grain or grain byproducts to keep the calcium to phosphorous ratio at least 1:1. Phosphorus is the most expensive mineral to supplement, thus targeted supplementation of phosphorus is important for cost effectiveness. Supplementation of phosphorus may be needed when cows are lactating, although early growth of grasses often has greater concentrations of phosphorus. Thus, depending on timing of calving, phosphorus supplementation may or may not be needed during early lactation (60-90 days post-calving). Forage phosphorus concentration and digestibility declines with advanced maturity and weathering. Thus, when feeding very mature forages (low quality grass hay or dormant range) to dry cows, phosphorus supplementation may be needed. However, if feeding a protein supplement, such as distillers or feeding supplemental alfalfa hay in the winter, additional phosphorus supplementation may not be needed. If the base forage (dormant range or mature hay) contains 0.10% P, then 2 lbs of dry distillers or 6 lbs of alfalfa hay will supply enough phosphorus to meet the needs of a dry cow.

Magnesium concentrations in forages often appear high enough to meet the needs of a cow. However, magnesium deficiency, referred to as grass tetany is a good example of a commonly occurring secondary deficiency. Rapidly growing immature grasses have high nitrogen and potassium content which can interfere with absorption of magnesium in the rumen, resulting in a deficiency of magnesium despite the intake of magnesium appearing to be adequate. This is most typically observed in lactating cows in the early spring as they have increased magnesium requirement and are eating lush cool-season forages. It is not as prominent in cows grazing warm-season perennial pastures or native range. Although it can also occur with dry cows in the fall that are brought back from range and allowed to graze lush meadow regrowth.

Trace mineral content of forages

Variability in the trace mineral content of forages is much greater than the variability in protein and energy content. Also, not all of the mineral in the forage will be absorbed by the animal. As a general guideline, it is typically assumed that only 50% of the trace mineral content of feeds and forages is available to the animal.

Nationally, a survey of serum concentrations of trace minerals in beef cows showed that zinc and copper are the most common deficiencies encountered. When looking at zinc and copper concentrations in forages this is not unexpected. On average, 25% of the cow's requirement for zinc is supplied by forage (when assuming 50% bioavailability). When supplementing zinc, care must be taken to prevent potential negative effects on copper availability. Therefore, mineral supplements should be formulated with a copper: zinc ratio of around 1:2 or 1:3. Only about 25% of the cow's copper requirement is supplied by the forage, again assuming 50% bioavailability from the forage. Additionally, elevated concentrations of copper antagonists (iron, molybdenum, and sulfur) are often encountered. The targeted intake of copper should be above the requirement, when these antagonists are present in the diet. Sulfur content above 0.25% will cause decreased availability of copper, especially if coupled with as little as 1 ppm of molybdenum. Thus, due to antagonists the amount copper in supplements often needs to provide 100 to 150% of their requirement. The manganese content of forage is usually sufficient to supply 50 to 80% of the cow's requirement (again assuming 50% bioavailability from forage). Iron content of the forages is above the requirement. Some producers have the idea that red mineral is better because it supplies iron but in fact due to its antagonist nature with zinc, copper, and manganese, iron supplementation can make your mineral program less effective. Iron content of the forage itself is often high enough to be antagonistic. The amount of selenium in forages is quite variable, generally, it is recommended to provide supplemental selenium (unless selenium toxicity has been observed in the area), when cattle are consuming brown forages which will have lower vitamin E content as the function of selenium and Vitamin E are interrelated. The difference between selenium adequate and selenium toxic levels is extremely narrow. Thus, if feeding multiple fortified supplements or using injectable minerals that supply selenium, it is important to pay attention to how much supplemental Se is being provided to avoid toxicity.

Free choice supplements

Due to convenience, grazing cattle are typically supplemented minerals via a free choice supplement. The issue with free choice supplementation is that cattle typically consume these supplements based on their taste for salt rather than their body's nutritional needs. Thus, it is important to know the targeted intake of the mineral and change location and/or salt content of the supplement based on the disappearance of the mineral. For instance, if intake is greater than needed moving the mineral away from areas of high traffic may help (i.e. move further from water source).

Typical levels of salt in these minerals range from 15 to 30% and can be adjusted based on intake. Using the lower level of salt allows for freedom to add salt on the ranch based on variation in intake. Even if the average intake of the herd is correct, some animals will be consuming more than is need and others less. However, using this supplementation method is still beneficial as compared with not supplementing.

Table 2.General guidelines for level of mineral for free choice supplementation of grazing cows[1]

			Amount on tag	
Mineral	Cow requirement	Will supply to total diet[2]	4 oz intake	2 oz intake
Selenium, ppm[3]	0.1	0.1 to 0.2	13 to 26	26 to 52
Copper, ppm[4]	10	10 to 15	1300 to 2500	2600 to 5000
Zinc, ppm[5]	30	15 to 22	2000 to 3000	4000 to 6000
Manganese, ppm[5]	40	10 to 20	1300 to 2600	2600 to 5200
Iodine, ppm	0.2	0.2	26	52
Cobalt, ppm	0.1	0.1	13	26
Magnesium, %[6]	0.12-0.20	0.03 to 0.10	3 to 13	6 to 26
Calcium, %[7]	0.16-0.40	0 to 0.10	0 to 13	0 to 26
Phosphorus, %[7]	0.13-0.23	0 to 0.10	0 to 13	0 to 26

1 Assumes a relatively available source of mineral is used (i.e. not copper oxide)
2 Assumes 1300 lb cow consuming 2.5% BW
3 Concentration of Se in forage vary in different regions
4 If high there is high Mo in forage use upper range otherwise lower level is sufficient
5 If feeding straw or winter range use upper range otherwise provide at lower level
5 If feeding straw or winter range use upper range otherwise provide at lower level
6 Use upper range if tetany is a concern (fall when moving back from range and grazing lush meadow regrowth and in early spring when grazing lush cool season grasses)
7 Keep calcium to phosphorous in mineral at least 1:1; during early lactation may need to provide Ca

Based on the typical concentrations of minerals in forages the following guidelines are a starting point when developing or selecting a free choice mineral supplement (Table 3) and can help one visualize the relationship between the amount of mineral being provided in the diet when feeding a 2 or 4 oz intake free choice mineral with various concentrations of minerals. However, sampling the forages produced on the ranch can help to refine supplementation choices,

and improve the cost effectiveness of the mineral supplementation program. The key when sampling forages is to minimize dirt contamination, sample the forages that are being selected for by the cattle at the time of sampling, and to sample at multiple times of the year to align forage mineral content with the appropriate supplement formulation. Given the year to year variation in forage mineral it is a good idea to do this over multiple years to get reasonable estimate of typical mineral content. Although this will require initial investments in labor and analysis, it can save money in the long run. Many commercially available mineral supplements are formulated to meet 100 to 125% of the animal's requirement. While this minimizes the likelihood of deficiencies, it also often supplies minerals in excess of the requirement, effectively causing the producer to pay for supplement that is not needed. Custom mineral supplements can be significantly less expensive due to the fact that they contain only the minerals that are lacking. Producers with larger herds should consider working with nutritionists/extension professionals to formulate mineral supplements that are customized to complement the mineral content of their forage and then have these formulations competitively bid.

Source of supplemental mineral

Looking at the concentration of a mineral on the tag of a free choice mineral will not tell you all you need to know. Different mineral sources have different availability to the animal (bioavailability). In general, inorganic sources are the most cost-effective means of supplying minerals to a beef cow. Research suggests that sulfate and chloride forms of various minerals are the most bioavailable of the inorganic sources, followed by carbonates, with oxides being the least bioavailable (Wright, 2007). For instance, copper sulfate is considered to be 100% bioavailable, while copper oxide is only 15% bioavailable. Thus you would need almost 7 times more copper from copper oxide to have the same amount of copper available to the animal. Zinc oxide is an exception and is equal to zinc sulfate (100% bioavailable). Organic sources can be beneficial when mineral antagonists (i.e. sulfur, molybdenum, iron), are present in large amounts or when a rapid change in status is needed. In these situations, it may be useful to provide 50% of the supplemental mineral in question from an organic source. Another option in these situations is to use an injectable trace mineral to increase status before key production periods (pre-breeding and pre-calving).

Conclusion

Providing supplemental mineral will not automatically improve production (weaning weight, weaning rate, etc.). A benefit will only be observed if correcting a deficiency, thus strategic supplementation based on the feed resources is the only way to develop a cost effective mineral program.

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