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Mineral Supplementation of Beef Cows in Texas

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The proper balance of protein, energy, vitamins and all nutritionally important minerals is needed to make a successful nutrition program, one that's productive yet economical. Nutrient balance is the key to any effective nutrition program, especially where trace minerals are concerned. **Today, there is concern that the trace elements may be limiting production in better managed herds to a much greater extent than generally recognized.** Simple starvation or hollow belly is still the primary limiting factor in many less well managed herds. Supplementation programs cannot economically overcome the negative effects of overgrazing. Be sure you have your nutritional management priorities in the proper order. It won't make you money to furnish cattle 150 percent of their mineral needs if they're only receiving 85 percent of their protein and energy needs or vice versa.

Historical, But Still Relevant Phosphorus Research

The importance of phosphorus supplementation in Texas has been realized ever since research studies in the 1930s

Please see Table 4, page 7, for detailed information on Recommendations on Mineral Supplements.

and '40s at the King Ranch. In Trials 1 and 2, percent calf crop weaned increased 40 and 41 percent, weaning weight increased 69 and 49 pounds, and calf weight weaned per cow exposed increased 156 and 165 pounds, respectively, with phosphorous supplementation (Appendix Table 1). Return per dollar invested in phosphorus, at today's prices, ranged from $3.95 to $12.35 depending on the method and amount of supplementation (Appendix Table 2). As a result of these studies, it became a goal of many cattlemen to supplement 6.0 pounds of actual phosphorus per cow per year. Six pounds of supplemental phosphorus intake/cow/year is still a reasonable goal for cows grazing on native, unfertilized pastures with little or no protein or energy supplementation. Educators and cattlemen mistakenly assumed that cows grazing improved fertilized pastures also needed as much as 6 pounds of phosphorus/cow/year. More is now known about the effect of forage type on mineral content and appropriate supplementation.

Recent Field Experience

Since 1986, direct field experience has occurred with more than 50 ranchers (most but not all in Texas) who were experiencing trace mineral nutrition problems in their herds. Production losses ranged from slight to severe. In one herd the calf crop fell to 55 percent after having run from 85 to 95 percent for years. In another herd, 10 out of the first 20 calves died soon after birth. In numerous herds, cattle often appeared wormy, but did not respond to deworming. The worst problems were always found in purebred continental breeds of cattle. Most problems involved the trace mineral copper and sometimes zinc and selenium. Mineral imbalances, rather than simple mineral

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deficiencies, were frequently found. Sulfur (>.3 percent) and iron (>250 PPM) levels were often high in diets which are antagonistic to copper and selenium utilization. Molybdenum, a well-known copper antagonist, was not extremely high, but would reach 2 to 3 PPM which is a problem when combined with high sulfur. This publication deals with a systematic approach to mineral supplementation based on experiences with these problem herds and data from research literature. Performance in these problem herds returned to acceptable levels with mineral supplementation practices described in this publication.

Need for Minerals

Maintenance, growth, lactation, reproduction and animal health cannot be optimized where mineral intake is not properly balanced. A full discussion of the functions and deficiency symptoms of all required minerals is beyond the scope of this paper. Libraries are filled with books on the subject. This discussion will center around mineral supplementation practices.

Increasing Emphasis on Trace Minerals

Trace mineral supplementation needs are greater today than ever before because:

1. More is known about their essential functions and production losses, resulting from marginal deficiencies which often existed in the past but were not recognized. In some cases requirements are simply more accurately defined today.
2. Genetic potential for performance and productivity of cattle has probably increased requirements. Today cattle are pushed to perform much nearer their genetic potential. Generally, a good job with protein and energy supplementation is practiced, but trace mineral nutrition hasn't kept pace.
3. In cattle, sheep and humans, **genetics can greatly influence copper requirements and susceptibility to toxicity**. For years it has been well-established that breeds of sheep vary in their susceptibility to copper toxicity and requirements for copper. Recent research indicates Simmental and Charolais cattle require more copper in their diet than Angus. Field experiences suggest that Simmental, Maine Anjou, Limousine and Charolais cattle all benefit from 1.5 times the copper intake normally defined for traditional breeds. On the other hand, it appears that Jersey cattle are much more susceptible to copper toxicity (possibly as low as 40 PPM of the diet compared to the normally accepted 100 PPM) than Holsteins. Brahman cattle may be more susceptible to copper toxicity than other beef breeds. Thus, you must carefully evaluate the needs of your particular breed of cattle. Genetic differences quite likely exist within all breeds.
4. Wherever yields of crops have been increased with nitrogen, phosphorus and potash fertilizers without accompanied repletion of trace elements, the content of many of the trace elements in feedstuffs has decreased over time. The decrease is especially true for shallow rooted crops.
5. Liming, fertilization practices and/or industrial pollution may be altering the composition or proportion of minerals in forages in certain areas.

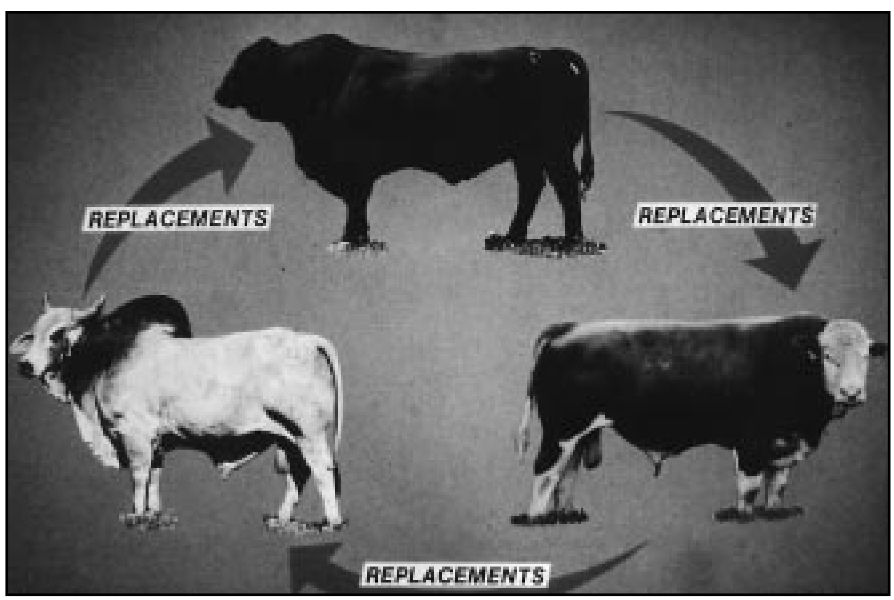

Figure 1. Various breeds have advantages and disadvantages in crossbreeding. Breed also has an influence on the amount of copper needed for reproduction and good health.

6. It has become evident in recent years that trace mineral deficiencies are the root cause or contributing factor for health problems and failures of commonly accepted disease treatments. Research with rats and mice over the last 10 to 15 years has established many of the biological mechanisms by which the body fights disease. Although other minerals may be involved, much work with copper, zinc and selenium has shown them to be essential to the immune system and the body's disease defense mechanisms (2)(3)(4)(5). On a more practical basis, research studies and numerous field cases reported by practicing veterinarians have related deficiencies of specific trace minerals to the frequency and severity of such problems as **mastitis, retained placenta, stillbirths, embryo mortality, general reproductive failure, weak calves and dummy calves at birth without good nursing reflexes, calf scours, abomasal ulcers in calves, pneumonia, and apparent vaccine failures**.
7. There is good evidence that a higher level (possibly 25 to 50 percent) of some trace minerals may be needed for good health than for normal growth. The appropriate levels remain to be defined, but there is work ongoing in this area.

Recommended Approach To Mineral Supplementation: "Balance Their Rations"

Successful commercial poultry, swine, dairy and feedlot operations all balance the rations for their livestock! Don't you think it's time ranchers do too?

Admittedly, a rancher can't balance the diet of a range cow as easily or as accurately as the manager of a confinement operation. However, the only way to solve mineral problems where excesses and deficiencies occur simultaneously is to make an effort to balance the ration.

The mineral-related performance problems in the herds mentioned earlier were solved by obtaining the necessary information and balancing the cattle's rations.

Information Needed

To balance rations, you must have the following information:

1. The nutrient requirements of the particular class of cattle: Include insurance levels desired to account for factors such as breed, genetic potential and inherent variation in feed composition.
2. The nutrient content of the feeds they eat:
   a) Book values are reasonably accurate for concentrate feeds and values are constantly being updated with new data. However, a recent report (Larry Berger, 1994 Florida Ruminant Nutrition Symposium, p.1) indicates that book values often overestimate the level of trace minerals in many common feedstuffs listed in the U.S. - Canadian Tables of Feed Composition. Copper content was often only 15 to 50 percent of commonly used book values for feeds such as corn silage, alfalfa, brewers and distillers grains, whole cottonseed, and cottonseed hulls. Zinc and manganese were usually within 70 percent of reported values or even higher than reported values in some feeds.

   b) Forage testing for minerals is often needed for grazing and hay crops. When sampling pastures, collect only the plants and parts of plants you observe the animals grazing. Available book values (National, State, Region, County) are a good place to start, but are often lacking or not accurate enough to be helpful since forages are quite variable in their nutrient contents compared to concentrates.
3. Mineral content of water: Water may frequently supply beneficial or detrimental levels of minerals such as sodium, chlorine, sulfur and iron. Some indicators include a salty taste for salt (sodium chloride), rust for iron and a bad taste or rotten egg smell for sulfur. However, water can contain significant levels of sulfur and not give off the rotten egg sulfur odor. If performance problems exist in the cattle and you're not sure about the quality of water, have the water analyzed.
4. An estimate of feed intake:
   a) Many guides to feed dry matter intake are available. A rough guide would be 1.5 percent of body weight for very coarse poor forage, 2.0 percent for average and 2.5 percent for good forage. Feed intake is almost always reduced with deficiencies of any mineral or excesses of minerals such as sulfur and molybdenum.

b) For small amounts of supplement (<.2 percent body weight), add the supplement intake to the forage intake. For supplement levels of 0.3 to 1.0 percent of body weight, decrease forage dry matter 0.6 pounds / pound of supplement dry matter intake.

Mineral Requirements

Table 1 contains a list of generally accepted mineral requirements and tolerances for beef cows. Considering possible increased requirements for health, increased performance, breed differences and variation in feeds, you will note many nutritionists "formulate" to levels above those considered minimal requirements. The amount of additional "insurance mineral" will vary with the specific mineral, its cost and the potential detrimental effects an excess may cause.

Many minerals interfere with the utilization of other minerals at levels well below the "maximum tolerable level." For example, it will usually be beneficial to increase the level of copper above that listed as the requirement any time molybdenum exceeds 2 PPM, sulfur exceeds 0.3 percent, iron exceeds 250 to 300 PPM or some combination exists. All minerals can be involved in interactions, but **the effect other minerals have on the need for copper appears more specific and unique** than with many of the other minerals.

When determining the level of total dietary mineral desired, and thus supplemental intake and formulation, keep in mind the following points:

1. Moderately higher levels of mineral intake, for up to six weeks, may be needed and safe for cattle with severe deficiencies, but should not be continued once their mineral status has returned to normal.
2. Relationships in cows have been well established between stage of production and requirements for major minerals, protein and energy; this is not true for trace minerals. Contrary to the generally higher requirements for protein, energy, calcium, etc., during lactation, **the requirement for copper and selenium may be equally high or even higher in late pregnancy than during lactation**. Since milk is low in copper, the cow must build the fetal liver concentration of copper

Table 1. Diet Formulation Guidelines

Mineral	1996 Beef NRC Requirements		Common Formulation		Maximum Limit
	Dry Cow	Lactating Cow	Dry Cow	Lactating Cow	
Calcium, %	0.25	0.25-0.36	1.6 X P[a]	1.6 X P[a]	2[b]
Phosphorus, %	0.16	0.17-0.23	0.17	0.24	1[b]
Potassium, %	0.6	0.7	0.7	0.8	3
Magnesium, %	0.12	0.2	0.15	0.22	0.4
Sodium, %	0.07	0.1	0.1	0.15	-
Chlorine, %	0.2[b]	0.25[b]	0.25	0.3	-
Sulfur, %	0.15	0.15	0.17	0.2	0.4
Iron, PPM	50	50	87	87	1,000
Manganese, PPM	40	40	70	70	1,000
Zinc, PPM	30	30	60	60	500
Copper, PPM[c]	10	10	17	17	100
Iodine, PPM	0.5	0.5	0.6	0.6	50
Selenium, PPM	0.1	0.1	0.2	0.3	2
Cobalt, PPM	0.1	0.1	0.2	0.2	10
Molybdenum, PPM	-	-	-	-	5

[a] p =phosphorus
[b] From 1989 Dairy NRC
[c] Copper requirements are highly variable (from 10 to 30 PPM). Levels of copper up to 30 PPM may be needed with some breeds of cattle where molybdenum is >2-3 PPM, sulfur is >.3%,iron is >300 PPM in the diet, or some combination exists. Include iron and sulfur from water. **Remember that high copper levels are toxic to sheep.** The Continental breeds of cattle have higher requirements and some breeds are more susceptible to toxicity, e.g., Jerseys and possibly Brahmans.

to about 3 times that of the adult level to get the newborn past the milk-only phase of growth. Newborns with low liver reserves of copper, selenium and other nutrients are subject to many of the health problems mentioned earlier.

More research is needed concerning the effects of minerals on fertility and health. There **are important trace mineral needs during pregnancy**, which if not met can lead to sometimes serious and prolonged problems in the offspring.

Forage Mineral Content

Forage testing is the foundation for establishing the need for and the amount of supplemental minerals. **Soil testing** can help explain forage composition, but is not reliable in directly evaluating the mineral status of the animal. Likewise, blood testing and liver analyses on any dead animals can add information on a herd's mineral status. However, **knowledge of estimated dietary mineral intake from both feed and water provides the basis for correcting deficiencies or adjusting for mineral excesses. Even crude estimates are more helpful than complete guesses**.

The results of approximately 12,000 analyses of forages submitted to the Texas A&M University Forage Testing Lab during 1988-92 are shown in Table 2. When comparing the results of improved bermudagrass to native grasses, two important points become apparent: (1) bermudagrasses tend to contain higher levels of phosphorus, potassium, sulfur and manganese but lower levels of iron. (2) The same mineral supplement is not appropriate for both forage types. Bermudagrasses, on average, contain twice the level of phosphorus of native grasses. If 6 pounds of phosphorus/cow/year is appropriate for cows grazing native forage, as suggested by the King Ranch phosphorus trials, then half that level, or 3 pounds of phosphorus/cow/year, should be adequate for cows grazing average or better bermuda pasture or hay.

Complete mineral analyses are lacking for many grazing environments. Generally, the native grass data would be expected to represent forages from native rangelands, and fertilized bermudagrasses should be typical of various grasses when fertilized or grown on soils with high fertility.

Many forbs and browse plants are higher in phosphorus than native grasses so the supplementation needed may fall between the native and bermuda examples.

An estimated average mineral content for annual forages, such as **wheat**, **oats** and **ryegrass**, is presented in Table 3. There is limited information for winter annuals and variation should be expected. However, moderate calcium and high phosphorus and potassium levels are typical.

Supplement Formulation

Once you have a good feel for the mineral content of the diet (both feed and water), compare the levels to those desired and develop a supplement to make up any deficiencies. Where

Table 2. Variation in Forage Mineral Composition[a]

	Bermudagrass		Native Grasses	
	Average	Commonly[b] Observed	Average	Commonly[b] Observed
Calcium, %	0.43	0.28 - 0.58	0.48	0.29 - 0.67
Phosphorus, %	0.21	0.15 - 0.27	0.10	0.04 - 0.16
Magnesium, %	0.17	0.12 - 0.22	0.12	0.07 - 0.17
Potassium, %	1.59	1.13 - 1.95	0.91	0.28 - 1.54
Sodium, %	-	0.02 - 0.05	-	0.02 - 0.05
Chlorine, %	-	0.2 - 0.6	-	0.2 - 0.6
Sulfur, %	0.34	0.22 - 0.46	0.13	0.07 - 0.19
Iron, PPM	115	31 - 199	205	43 - 367
Manganese, PPM	86	35 - 137	50	25 - 75
Zinc, PPM	23	15 - 31	21	13 - 29
Copper, PPM	6.4	4 - 9	5	3 - 7

[a]Approximately 12,000 samples analyzed by the Texas A&M University Forage Testing Lab 1988 - 1992. Includes both hay samples and pasture clippings.
[b]Equal to the average + or - one standard deviation.

Table 3. Assumed Forage Composition for Recommendations Made in Table 4

Mineral	High Quality Summer Pasture or Hay, Well Fertilized	Bermuda Pasture or Hay, Fertilized	Native Pasture or Hay, Non-Fertilized	Grass Tetany Prevention, Annual Winter Pasture
Calcium, %	0.45[a]	0.43[b]	0.48[b]	0.35[a]
Phosphorus, %	0.28	0.21	0.1	0.35
Potassium, %	1.8	1.59	0.91	3.0
Magnesium, %	0.2	0.17	0.12	0.15
Salt, % -	-	-	-	
Sulfur, %	0.25	0.34	0.13	0.3
Iron, PPM	115	115	205	150
Manganese, PPM	50	86	50	60
Zinc, PPM	22	23	21	22
Copper, PPM	6	6	5	6
Iodine, PPM[c]	0.1	0.1	0.1	0.1
Selenium, PPM[c]	0.1	0.1	0.1	0.1
Cobalt, PPM[c]	0.1	0.1	0.1	0.1

[a]All values in this column are from unpublished data except for footnote[c].
[b]All values in this column are from Table 2 except for footnote c.
[c]These values are assumed from very limited data.

mineral content of the diet is unknown, formulate the trace mineral supplement to provide 50 to 100 percent of the National Research Council requirement for trace minerals. For many forages in Texas, supplementing 50 to 100 percent of the NRC requirement results in trace mineral levels in the total diet similar to those in Table 1 under "Common Formulation." If the mineral content of the supplement is kept in general proportion to animal requirements, it tends to pull the total diet mineral (forage + water + supplement) toward balance. This approach works well when forage mineral content is unknown.

Where you are comfortable that you know dietary mineral intake, probably from a combination of book values, feed analysis, guaranteed supplement analyses, and other facts, adjust individual mineral levels to meet your formulation goals. It is often good to keep a minimal level (e.g., 30 percent of the requirement) of some minerals in the supplement even though forage levels appear adequate, since the bioavailability of trace minerals in forage is often low. Use only forms and sources of minerals known to be reasonably high in digestibility, absorbability and bioavailability.

Supplement Intake

A 50 pound sack of 12 percent phosphorus mineral will provide a cow 6 pounds of actual phosphorus per year—a reasonable level for cows on native pasture. Three pounds of phosphorus from 50 pounds of a 6 percent mineral should be adequate for cattle on average or better bermuda forage, hay or pasture. Decrease expected mineral supplement intake appropriately for each pound of phosphorus supplied from protein-energy supplements. One pound of phosphorus is contained in 100 pounds of a protein supplement with a 1 percent phosphorus content.

Fifty pounds per cow per year averages 2.2 ounces per day. It is common for lactating cows to consume 2 to 2.5 times more mineral when lactating than when dry. Cows consumed an average 4.2 grams of phosphorus/day during their 3 months' dry period, 6.2 grams during a 2 month transition period at calving and 9.2 grams during a 7 month lactation in the King Ranch study. This equates to 1.25, 1.85 and 2.75 ounces, respectively, for the 3 periods or a ratio of .68, 1.0 and 1.48, respectively. Daily and weekly consumption levels will be even more variable. Numerous factors affect mineral consumption, including genetic potential of the cattle, forage mineral and moisture content, levels in water, palatability of the supplement, salt levels, mineral intake from protein-energy supplements, feeder location relative to water and loafing areas, etc. Cattle will normally consume more salt on high moisture diets. **Mineral consumption must be monitored**

and managed monthly so that appropriate adjustments can be made to arrive at an appropriate seasonal and annual intake.

General Mineral Supplement Recommendations

Four separate mineral supplements are outlined in Table 4 for cows grazing varying forage types. Keep in mind that alternative formulation can easily be obtained by mixing in various proportions of the four basic supplements. Recommendations in Table 4 were based on forage composition shown in Table 3.

Supplementation Practices

Some points to consider include the following:

1. Do not trust cattle to eat minerals if they need them and leave them if they don't. Cattle have certain "nutritional wisdom" relative to their need for salt and they will crave bones when phosphorus is deficient, but not necessarily phosphorus minerals. You have to manage the mineral nutrition of your cattle just as you do protein and energy.

Mineral deficient cattle will normally consume several times the recommended level for a given supplement. Allow cattle excess consumption for 10 to 14 days before taking steps to regulate intake. Some salt normally encourages supplement intake, but there are areas where either grass, water or both are salty and salt discourages supplement intake. High levels of salt in the supplement will decrease intake. Molasses, grain, cottonseed meal, etc., at 5 to 15 percent of the supplement, will encourage intake. Coating minerals with vegetable

Table 4. Recommendations on Mineral Supplement Composition for Beef Cows with Varying Forage Types Based on Mineral Contents Shown in Table 3.

Mineral	High Quality Summer Pasture or Hay, Well Fertilized + Trace Mineral Salt	Bermuda Pasture or Hay, Fertilized + 15:6:5 Mineral	Native Pasture or Hay, Non-fertilized + 12:12:4 Mineral	Grass Tetany Prevention Annual Winter Pastures + 16:2:10 Mineral
Intake, oz/cow/day=	1	2.2[a,b,h]	2.2[a,c,h]	2.5
Calcium, %	-	15[d]	12	16
Phosphorus, %	-	6	12	2
Potassium, %	-	-	-[e]	-
Magnesium, %	-	5	4	10
Salt, %	80+	<15[f]	<15[f]	15-25
Sulfur, %	-	-[g]	2-3[e]	0-3
Iron, %	-[g]	-[g]	-[g]	-[g]
Manganese, %	0.5	0.3000	0.4000	0.4000
Zinc, %	1.6	0.8000	0.8000	0.8000
Copper, %	0.5	0.2500	0.2000	0.2500
Iodine, %	0.016	0.0100	0.0100	0.0100
Selenium, %	0.01	0.0040	0.0040	0.0040
Cobalt, %	0.007	0.0030	0.0030	0.0030

[a]50 lb/cow/year, consumption will vary from 0 to 4.5 oz/cow/day - see discussion in text.
[b]3 lb phosphorus/cow/year.
[c]6 lb phosphorus/cow/year.
[d]Higher calcium is recommended to offset the detrimental effects of high sulfur.
[e]include in protein supplement when needed in order to obtain adequate intake.
[f]Provide additional salt if consumption is excessive.
[g]Add none above that are contained in other mineral compounds used.
[h]If vitamins are included, levels of vitamin A of 200,000 to 400,000 I.U. and levels of vitamin D of 15,000 to 40,000 I.U./pound of mineral supplement are reasonable assuming high quality, stable sources of vitamins and an average 2.2 ounces of mineral consumption/day.

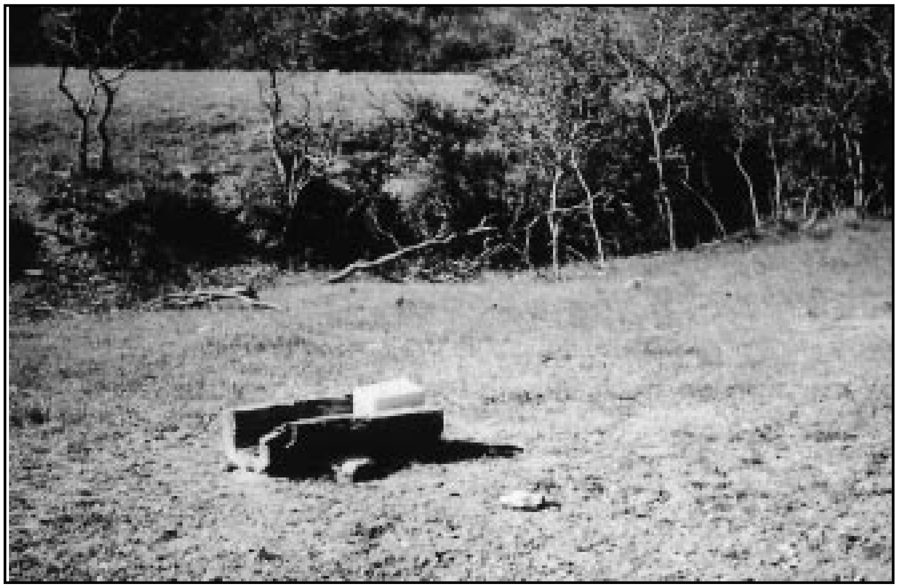

Figure 2. A salt block will not contain all of the supplemental minerals needed by most herds of cattle.

oils to reduce immediate chemical reaction on the cattle's tongue will enhance palatability. Manufacturing processes such as prilling will also aid palatability by reducing mineral dust.

2. If supplementing protein and/or energy, include minerals in the protein energy supplement. Copper deficiency in cow herds can occur when self-limiting feed supplements containing salt and phosphorus are fed. Cattle quit eating high copper mineral supplements, and the feed supplement is usually too low in copper to act as a copper supplement. This same scenario could apply to other trace elements.
3. Mineral feeders should be low enough so calves can reach the mineral. Minerals formulated for cows will work for replacement heifers when consumed at slightly lower levels. However, it would be better to use a mineral supplement formulated for stocker cattle where ionophore feed additives, etc., may be included.

Pricing Supplements

Do not be fooled by a mistaken concept that "the higher the concentration of minerals in a supplement, the better it is." For example, consider supplement A (cost $500/ton, phosphorus 12 percent, copper 0.2 percent and consumption 2 ounces/cow/day) and supplement B (cost $250/ton, phosphorus 6 percent, copper 0.1 percent and consumption 4 ounces/cow/day), to be equal. Just because supplement A contains twice as much phosphorus and copper doesn't make it better when the cows will eat only half as much and it costs twice as much. It is the actual amount of each mineral consumed by the cow that counts, not the percentage or proportion of mineral in the supplement. To determine supplemental mineral consumption, look at both the supplement intake and the concentration of mineral in it. A reasonable minimal amount of the various minerals must be in a supplement, but making supplements too concentrated sometimes causes palatability problems, especially with minerals like magnesium.

Bioavailability

As a general rule, the bioavailability of inorganic mineral sources follows this order: **sulfates = chlorides > carbonates > oxides**. Recent research indicates **copper oxide is a very poor source of copper** for use in mineral supplements. Because of a much longer

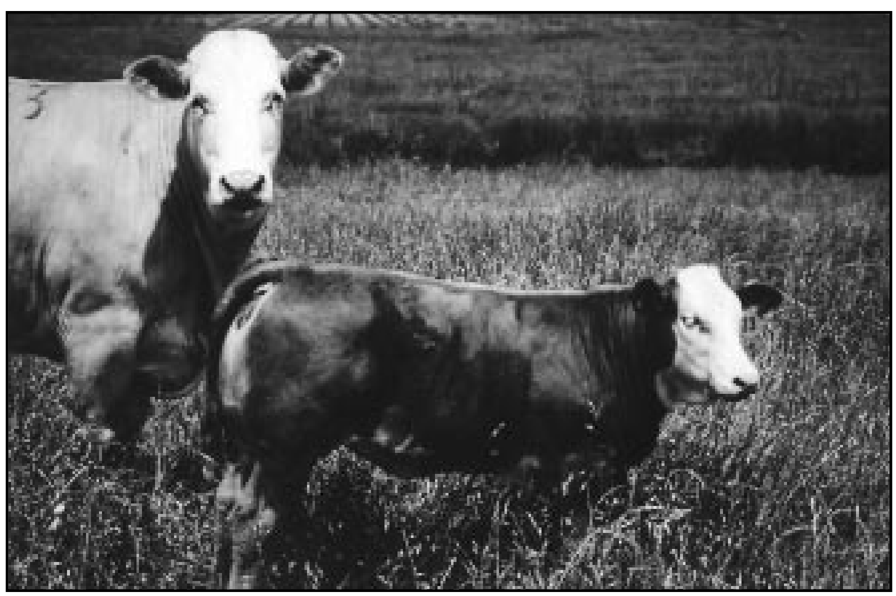

Figure 3. Minerals are important in the development of young animals, as well as for the cow. Be sure mineral supplements are accessible by calves.

retention time in the gut for absorption, copper oxide needle boluses are effective copper sources. Iron oxide, which is used as a red coloring agent for minerals, is poorly available but may still act as an antagonist to copper absorption.

At this time, confusion reigns about the role of organic forms of trace minerals (proteinates, complexes and chelates). Evidence is accumulating that specific products may be absorbed by different pathways and transported and metabolized by different routes making them more effective in specific situations. However, specific situations are not well-defined so one can carefully consider the economic consequences of using organic sources versus inorganic sources.

The organic forms of some of the trace minerals may be of greater value when an animal is under nutritional, disease or production stress. Since organic forms cost more than traditional inorganic forms, increased production must be obtained for a profit to be realized.

Mineral chelates, complexes and proteinates are not chemically equal. Mineral proteinates will be more variable in their chemical structure, and possibly their physiological function, than a specific amino acid-mineral complex, e.g., zinc methionine. Much work remains to be done to sort out the chemistry, digestibility, bodily function, quality control or product consistency, and economic benefit of the organic forms of trace minerals which are available today. **In the meantime, use a systematic step-wise approach to mineral supplementation.**

Figure 4 outlines an approach to the selection of mineral products. There are areas and times when forages provide all the minerals the cattle need, especially if the level of production is low (point A in Figure 4). However, this situation is not widespread. For many cow-calf operations, using a well-formulated inorganic mineral supplement containing only the cheaper and readily available sulfate, chloride or carbonate forms in adequate amounts will work very well (point C in Figure 4). There is no place for using nondescript supplements (point B in Figure 4) with imbalanced mineral levels, frequently containing the less available oxide forms and with cost approaching that of the well-formulated inorganic supplements.

Many beef herd managers use inorganic mineral supplements where performance is excellent so it is hard to visualize a potential for increased profit by spending more money with little opportunity for increased production.

On the other hand, when dealing with nutritional stress such as high sulfur, molybdenum and iron, occasionally responses to inorganic mineral supplements may not be satisfactory. Extremely high levels of production, flushing a donor cow, frequent collection of an A.I. bull, weaning, transition to high energy rations, excess fat on cows, calving and nutritional insults from unbalanced diets, molds, etc., may all constitute stress.

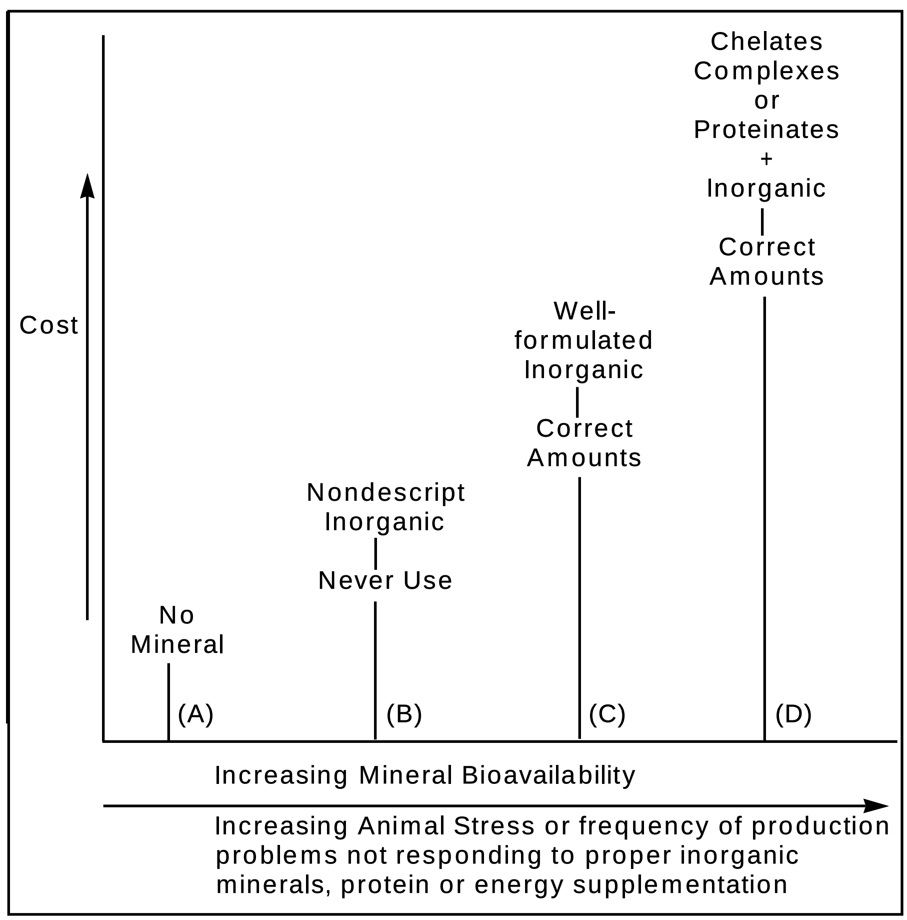

Figure 4. Systematic selection of trace mineral supplements.

What is suggested to the producers is an orderly progression of mineral supplement selection. If you haven't supplemented minerals previously, do so with a good inorganic but inexpensive supplement. **Make sure you have managed for appropriate intake of various minerals before you assume they are not working (point C in Figure 4).** If you have done this, and still have problems, go to a combination of inorganic and organic sources (point D in Figure 4). Where problems exist, pay something extra to fix them, especially when reproduction is involved.

Year-round use of organic mineral sources generally cannot be economically warranted. In some herds, targeting specific periods such as precalving and breeding may be warranted. Consider therapeutic use as opposed to routine use. This paper has outlined some of the factors you will need to evaluate in order to make an organized decision.

Summary

The old adage **"if it's not broke, don't fix it"** is especially appropriate when considering changes in a mineral supplementation program. Research and observations from the field emphasize, more than ever, the delicate balance among minerals which is necessary if biological efficiency is to be realized. It's easy to consider only one mineral at a time without giving due attention to interactions among minerals which affect individual mineral utilization and requirements.

On the other hand, we shouldn't become apathetic and defeatist just because the problem is complex and we don't have all the answers. We have more answers today than ever and more are being discovered all the time. **Minerals are no more important in good nutrition today than they've ever been, but today we recognize problems in production, especially in the areas of health and possibly, reproduction that can be corrected, with proper mineral supplementation.**

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Appendix Table 1
Results of Phosphorus Supplementation

Phosphorus Supplementation:

Trial 1 King Ranch 1938-41, (2 yr./avg.)
- *increase calves born from 64 to 85%, + 21 calves/100 cows
- *increase calves weaned from 58 to 81%, + 23 calves/100 cows
- *increase of cows calving in two consecutive years from 30 to 73%
- *increase weaning weight 69 lbs. (425 to 494)
- *increase weaning weight/cow 156 lbs. (244 to 400)

Trial 2 King Ranch 1942-46, (4yr./avg.)[a]
- *increase calves weaned from 64 to 90%, + 26 calves/100 cows
- *decrease calving interval from (459 to 366), - 93 days
- *increase weaning weight 49 lbs. (489 to 538)
- *increase wean weight/cow 165 lbs. (319 to 484)

[a]Average of bonemeal and water treatment vs. control

Appendix Table 2
Return on Investment In Phosphorus Supplementation[a]

Treatment	Cost[b]	Increased[c] Income	Return/ $ Invested
Control	—	—	—
Bonemeal, TM (4.5)[d]	7.97	98.40	12.35
Bonemeal (10.1)	17.88	75.60	4.23
DiNa PO_4 (10.1)	17.88	105.60	5.91
Bonemeal (5.6)	9.91	89.40	9.02
DiNa PO_4 (6.4)	11.33	108.60	9.59
P Fertilizer (79)	47.40	187.20[e]	3.95

[a]In the 1938-41 trial, cattle were manually fed (1) bonemeal with trace minerals to supplement 6.5 grams of phosphorus/cow/day all year long (4.5 lb. P/year), (2) bonemeal to supply 6.5 grams during dry period and 14.3 grams during lactation (10.1 lb P/year), or (3) disodium phosphate at the 6.5 - 14.3 (10.1 lb. P/year) rate. In the 1942-46 trial (1) bonemeal was self fed, (2) disodium phosphate was added to the water (1.08 grams P/gallon) and (3) pastures were fertilized with 200 pounds of triple superphosphate (96 lb P_2O_5) per open acre (88% of total acres) one time for 5 years.

[b]P@$1.77/lb. = $425/ton for 12% P mineral - Fertilizer P @ $.60/lb

[c]Calf weight @ $.60/lb

[d]( )lb.P/cow/year

[e]1.5 X more cows/unit of grazing land

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