Forage Research in Texas, 1993

Mineral Concentrations of Selected Texas Forages and Beef Cattle Mineral Requirements

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Summary

Approximately 12,000 forage samples submitted to the Texas A&M University Extension Soil, Water and Forage Testing Laboratory during 1988 to 1992 were analyzed for mineral content. The data suggest a widespread occurrence of deficient levels of plant phosphorus, copper, and zinc for beef cattle grazing Texas forages. Mineral concentration distribution of the native and bermudagrass forages indicate important differences for grazing cattle. A numerically greater percentage of native forage potassium, phosphorus, copper, and zinc concentrations (38, 88, 45, and 52%) were categorized as deficient for all classes of beef cattle compared with bermudagrass forage concentrations (1.5, 21, 19, and 38%). These data indicate that cattle grazing native or bermudagrass forage require different formulations of mineral supplements for optimal production.

Introduction

Mineral requirements of grazing cattle depend on stage of animal growth and production, breed type, and environmental factors including those that are associated with stress and pathogenic invasion. The dietary mineral intake needed to satisfy the animal's requirement varies with the chemical form of the mineral and the presence or absence of dietary components that either enhance or restrict mineral absorption. Forage mineral concentrations vary considerably because of several factors including forage type, stage of growth, climatic conditions, and availability of soil minerals for plant uptake. Grazing livestock can become deficient in minerals when forage mineral concentrations are inadequate, or when minerals interact with other dietary constituents to reduce mineral absorption. Quantifying the mineral status of grazing ruminants is difficult and generally requires several diagnostic tests to predict with confidence.

A first step in identifying the mineral needs of livestock is to quantify the mineral concentration of the predominant forages being grazed. Mapping soil and forage mineral concentrations has been effective in identifying geographic areas where low or toxic levels of soil and plant mineral concentrations may pose a nutritional problem for grazing ruminants (Kubota 1968, Alloway 1972, NRC 1983). The primary objective of the current study was to characterize potassium (K), calcium (Ca), phosphorus (P), magnesium (Mg), sulfur (S), copper (Cu), zinc (Zn), manganese (Mn), and iron (Fe) concentrations from sample populations of forage samples collected across Texas.

Keywords: bermudagrass / native / mineral / cattle.

Procedures

The forage mineral concentrations used in this study were assembled from forage reports issued by the Extension Soil, Water and Forage Testing Laboratory on the campus of Texas A&M University to its clientele over the 5-year period 1988 to 1992. Knowledge of the forage sample is limited to that issued in the original report. Fertilization practices associated with the forage sample are unknown.

Approximately 88% of K, Ca, P, and Mg and 43% of S bermudagrass concentrations were analyzed by near infrared reflectance spectroscopy (NIRS) (ISI 1991). Micro minerals in bermudagrass and the mineral concentrations of native forage were analyzed by the wet chemistry (WC) procedure as outlined by Parkinson and Allen (1975), followed by determinations using inductively coupled arson plasma emission spectrophotometry. Initial comparison between NIRS and WC techniques for estimating mean concentrations of bermudagrass K, Ca, P, Mg, and S concentrations indicated that the NIRS analysis estimated mean K, Ca, P, and Mg concentrations 7 to 15% greater ($P < 0.001$) and mean S concentrations 7% lower ($P < 0.001$) than that estimated by WC. Therefore NIRS values for these minerals in bermudagrass were adjusted to WC values on the basis of the following assumptions: (1) that bermudagrass samples analyzed by NIRS and WC estimate the same population and (2) that the adjustment factor is consistent over the range of mineral concentrations in the data. The adjustment factor was calculated by dividing WC-estimated mean mineral concentration by NIRS-estimated mean mineral concentration.

Frequency histograms of the number of observations within a prescribed range of forage mineral concentrations are presented to provide data on the sample population. The range within the categories of forage mineral concentrations presented in the histograms (Figs. 1 to 18) are represented by either 0.25, 0.50, or 1 times the standard deviation of the common population. Mineral requirements for a mature, nonlactating beef cow (NRC 1984) were used to determine break points between categories where necessary to relate forage mineral content to animal mineral requirements. The original data base contained extremely high and extremely low mineral concentrations for both forages and for each mineral analyzed. Therefore, observations separated from the sample population mean by ±3 standard deviations have been excluded from Figures 1 to 18. In all cases, these observations represented less than 1.5% of the total sample. Bermudagrass pasture and bermudagrass hay was pooled, and native pasture and native hay was pooled. Forage mineral concentrations are presented on a dry matter basis. The *t* test procedure was used to determine differences in mean mineral concentration between forage types (SAS 1985).

Results and Discussion

For comparison between forage mineral concentrations and cattle mineral requirements, Table 1 presents mineral requirements estimated for various classes of beef cattle (NRC 1984; NRC 1988). Water, soil, and supplemental feeds contribute to total mineral intake in addition to forage and should be considered when evaluating animal mineral status. Reference material should be consulted to determine the mineral concentration required for a particular group of cattle in differing production environments (NRC 1984; NRC 1988; ARC 1980).

Bermudagrass forage had greater ($P < 0.0001$) mean concentrations of K, P, Mg, S, Cu, Zn, and Mn than did native forage (Figs. 1, 2, and 5 to 16). Native forage had greater ($P < 0.0001$) mean concentrations of Ca and Fe than did bermudagrass (Figs. 3, 4, 17, and 18). The greater average K, P, and S concentrations of bermudagrass compared with native forage are presumably due to forage type and soil conditions and to fertilization with these minerals in the production of bermudagrass. The greater average concentration of Cu, Zn, and Mn for bermudagrass compared with native forage may also reflect forage type, soil conditions, and agronomic practices associated with bermudagrass production that result in changes in soil pH and mineral availability for plant uptake. The greater Ca and Fe concentration of native forage compared with bermudagrass forage is a common observation in this laboratory (unpublished data). Bermudagrass dominates the eastern third of Texas, and native forage dominates central and west Texas. Soil Ca and Fe concentrations increase from east to west because of increasing pH and decreasing rainfall.

Approximately 90% of the bermudagrass population K concentrations ranged from 0.65 to 2.09%; 1.5% were deficient and 8.6% were potentially excessive for mature, nonlactating cattle (Fig. 1). In comparison, 57% of the native forage population K concentrations

Table 1. Mineral requirements[†] (dry matter basis) for different classes of beef cattle.

Mineral	Mature, non-lactating cow	Mature, lactating cow	Medium frame 500-lb steer
	%		
Calcium	.21 - .25[††]	.28 - .48	.25 - .69
Phosphorus	.17 - .20	.22 - .31	.17 - .32
Magnesium	.05 - .15	.15 - .25	.10 - .15
Potassium	.65 - .80	.80 - 1.00	.65 - .80
Sodium	.06 - .10	.18	.06 - .10
Chlorine	.12 - .20	.25	.12 - .20
Sulfur	.08 - .15	.12 - .18	.10 - .15
	ppm		
Iron	50	50	50
Manganese	20 - 50	50	50
Zinc	20 - 40	40	40
Copper	5 - 10	10	10
Iodine	.20 - 2.0	.50 - 2.0	.20 - 2.0
Selenium	.05 - .30	.20 - .30	.30
Cobalt	.07 - .11	.07 - .11	.07 - .11

† NRC 1984; NRC 1988. Recent research suggests trace element requirements for optimal immune function may be greater than those listed herein.

†† Ca = 1.25 X phosphorus.

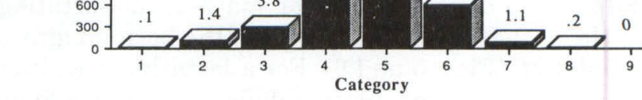

Figure 1. Number of observations within each category of K concentration (% dry matter) for bermudagrass forage. Number above column is the percentage of the population within that category.

ranged from 0.65 to 2.09% K, 38% being deficient and 5.2% being excessive (Fig. 2).

Previous data from our laboratory (Greene et al. 1987) show that stage of growth is important when predicting forage K concentrations. Actively growing plant tissue is much higher in K content than is dormant tissue. In general, cattle grazing actively growing fertilized pastures will acquire adequate quantities of K in the forage diet. However, if forages are not fertilized and/or are dormant, additional K in free-choice supplements may prove advantageous. Unlike most minerals, no physiological storage depot for K exists, and adequate amounts must be supplied daily either from the forage base or from supplements. Excessive intake of K (> 2.1%) may reduce the absorption and utilization of Mg. An excessive intake of K is not a practical problem when cattle consume either bermudagrass or native forages.

Data presented in Figures 3 and 4 show that 8.6% of the bermudagrass and 2.1% of the native forage were extremely deficient in Ca. Most of the forage Ca concentrations ranged from 0.31 to 0.66%. The percentage of the population within this range was 71% for bermudagrass and 71.8% for native forage. The Ca requirement of forage-fed cattle is highly variable and depends upon stage and level of production. As shown in Table 1, the requirement for Ca ranges from 0.21 to 0.48% for cows and 0.25 to 0.69% for steers. The NRC requirement for Ca in steers is based upon growth rate and dry matter intake. Steers fed bermudagrass or native forage diets will probably not realize high enough growth rates to require more than 0.4% Ca. The amount of Ca required in forage also largely depends upon the relationship of Ca with other minerals. Typically, metabolic disorders are more prominent when P levels are high relative to Ca, especially on highly fertilized productive forages. Without adequate liming of acid soils that have been fertilized with P, Ca is often too low relative to P. On the other hand, Ca is relatively high and P very low in unfertilized forages produced on alkaline soils in certain regions of the state.

A large numerical difference existed between native and bermudagrass forage in the percentage of the population deficient in P. Most native forages (88%) were deficient in P for mature, nonlactating cattle compared with only 21% of the bermudagrass population (Figs. 5 and 6). For a lactating cow, that proportion of the population deficient in P would be approximately 65% of bermudagrass and 96% of native forages. Common mineral supplements used throughout Texas for many years have supplied equal

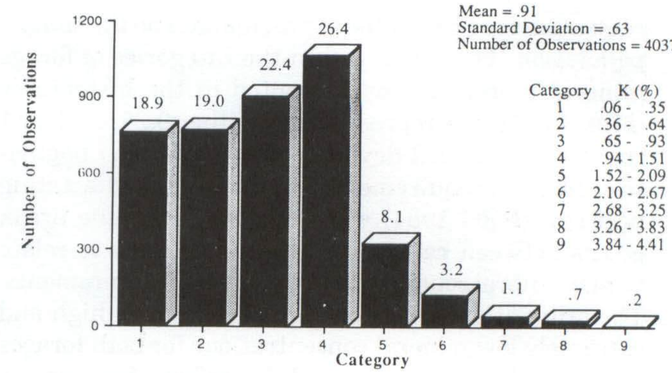

Figure 2. Number of observations within each category of K concentration (% dry matter) for native forage. Number above column is the percentage of the population within that category.

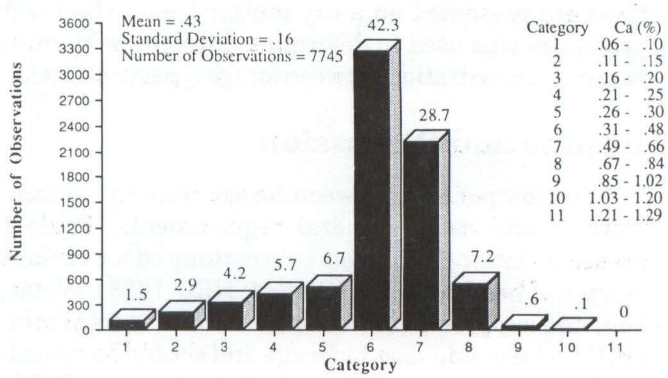

Figure 3. Number of observations within each category of Ca concentration (% dry matter) for bermudagrass forage. Number above column is the percentage of the population within that category.

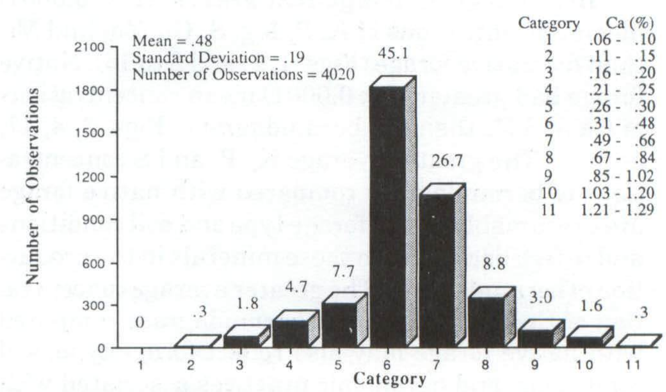

Figure 4. Number of observations within each category of Ca concentration (% dry matter) for native forage. Number above column is the percentage of the population within that category.

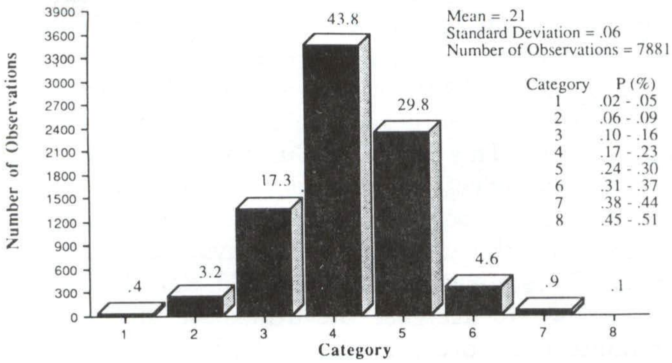

Figure 5. Number of observations within each category of P concentration (% dry matter) for bermudagrass forage. Number above column is the percentage of the population within that category.

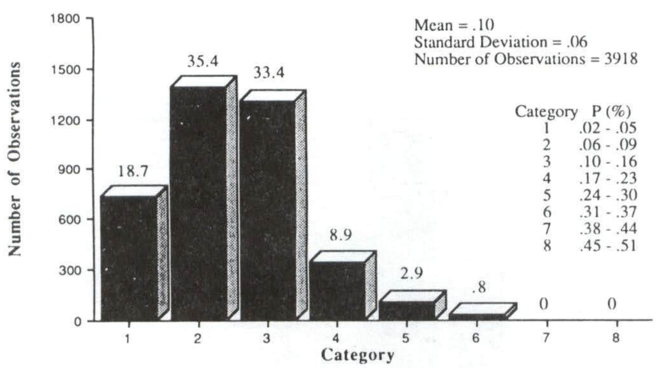

Figure 6. Number of observations within each category of P concentration (% dry matter) for native forage. Number above column is the percentage of the population within that category.

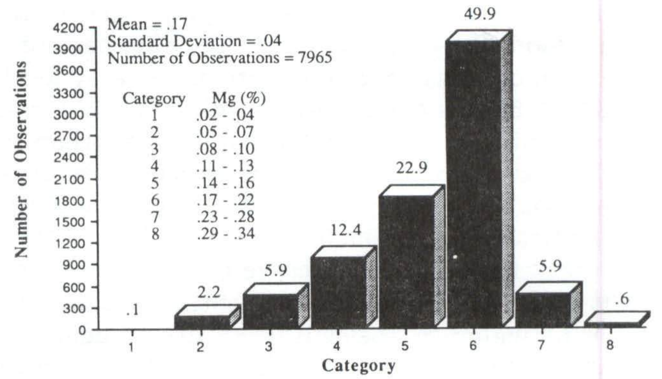

Figure 7. Number of observations within each category of Mg concentration (% dry matter) for bermudagrass forage. Number above column is the percentage of the population within that category.

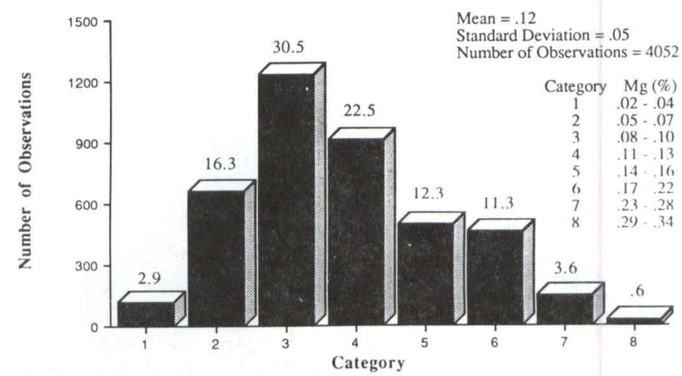

Figure 8. Number of observations within each category of Mg concentration (% dry matter) for native forage. Number above column is the percentage of the population within that category.

portions of Ca and P, and a 12:12 percentage of Ca and P is still required in mineral supplements for many production environments. However, when cattle graze forages fertilized with P yet low in available Ca, mineral supplementation programs will be more cost effective if the P content is reduced by approximately 50% to supply a supplement of 12% Ca and 6% P. In the present data, approximately 74% of the bermudagrass and 8.9% of native forage P concentrations ranged from 0.17 to 0.30%. Native forages in Texas are predominately deficient in P, and P must be supplied as a supplement to optimize production.

According to the NRC recommendations, only a small proportion of bermudagrass (0.1%) and native (2.9%) forage was deficient in Mg for a mature, nonlactating cow (Figs. 7 and 8). Seventy three percent of bermudagrass forage Mg concentrations ranged from 0.14 to 0.22% compared with 24% of the native population. Most of native forage Mg concentrations (53%) fell within a range of 0.08 to 0.13%.

From a practical standpoint, Mg deficiency (grass tetany) is not reported to be a problem when cattle graze native pastures. Cattle grazing bermudagrass pastures typically have an adequate Mg supply to meet the Mg requirements. It is well known that high (> 2.1%) dietary K (as seen in rapidly growing winter pastures) will interfere with Mg utilization. However, dietary K in bermudagrass and native forage is not typically high enough to reduce Mg availability.

No bermudagrass forage was deficient in S compared with 9.9% of the native population having forage S concentrations less than those recommended by NRC (Figs. 9 and 10). Of more importance in the bermudagrass population is the proportion of the population with excessive levels of S. Fifty percent of the bermudagrass S concentrations were at levels (0.32 to 0.67%) that have been implicated in reducing Cu utilization and/or dry matter intake. Less than 1% of the native S concentrations were considered to be excessive. Sixty five percent of bermudagrass S concentrations ranged from 0.20 to 0.43%. Most of the S concentrations in native forage (73%) ranged from 0.08 to 0.16%. Sulfur supplementation is advised when native forage is below 0.10% S. In bermudagrass, elevated levels of S that result in a reduction in Cu availability is more of a practical problem for cattle than is S deficiency. When forage S levels rise above 0.30%, additional Cu should be provided.

The percentage of the population deficient in Cu was numerically greater in native compared with bermudagrass forage (Figs. 11 and 12). Approximately 45% of the native forage and 19% of the bermudagrass forage Cu concentrations were categorized as deficient for all classes of cattle. Approximately 76% of bermudagrass and 54% of native forage Cu concentrations were within a range of 5 to 10 parts per million (ppm). This range of Cu concentrations is adequate for beef cattle if no antagonists are present, a situation that rarely exists. Interactions of dietary components with Cu that reduce Cu availability can increase Cu requirements 1.5- to 4-fold. Both Fe and S are known to decrease the utilization of Cu in ruminants. In the present data, S is high in 50% of the bermudagrass forage, and Fe is high in 35% of the native forage. The distribution of Cu concentrations shown in Figures 11 and 12 indicate that forage Cu levels are not adequate to maintain reproductive response, calf growth, animal health, and maximum production efficiency in many situations. Therefore,

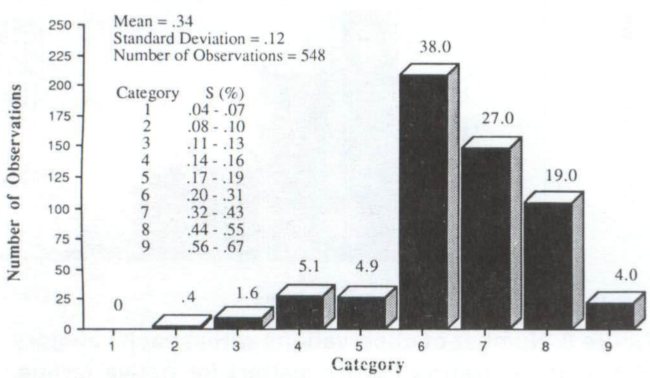

Figure 9. Number of observations within each category of S concentration (% dry matter) for bermudagrass forage. Number above column is the percentage of the population within that category.

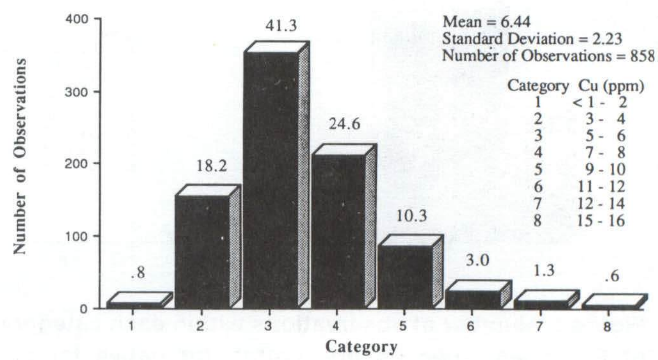

Figure 11. Number of observations within each category of Cu concentration (ppm dry matter) for bermudagrass forage. Number above column is the percentage of the population within that category.

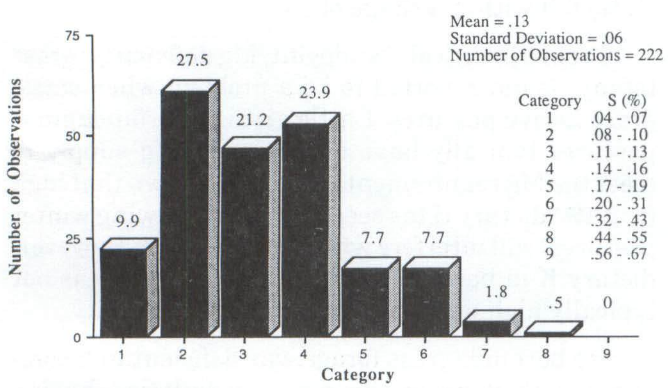

Figure 10. Number of observations within each category of S concentration (% dry matter) for native forage. Number above column is the percentage of the population within that category.

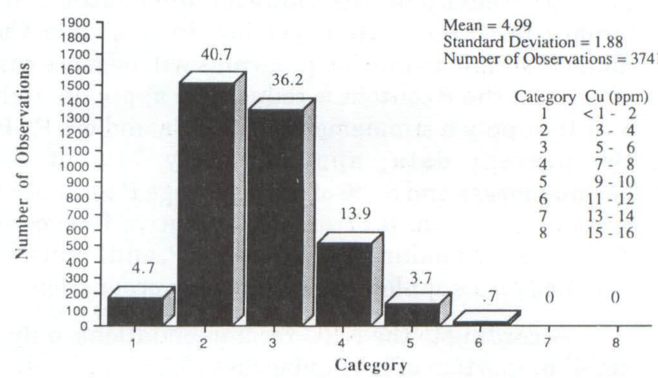

Figure 12. Number of observations within each category of Cu concentration (ppm dry matter) for native forage. Number above column is the percentage of the population within that category.

most mineral supplementation programs should supply Cu to forage fed animals in Texas.

NRC recommendations indicate a widespread occurrence of deficient levels of Zn for cattle fed bermudagrass and native forages (Figs. 13 and 14). Approximately 97% of bermudagrass and 98% of native forage Zn concentrations are below levels usually recommended for beef cattle (Table 1). Zinc deficiency will result in lowered fertility, lower weaning weights, and increased health-related problems. Current information relating Zn to immune function suggests that Zn requirements should be re-evaluated and may be greater than previously estimated. Zinc should be a component of mineral supplements for cattle in Texas to optimize production efficiency.

Both bermudagrass and native forage types exhibited a large range in Mn concentrations – 3 to 285 and 3 to 149 ppm, respectively (Figs. 15 and 16). The average Mn concentrations were approximately 2.3 and 4.1 times that typically recommended for beef cattle for native forage and bermudagrass forage, respectively. However, 52.8% of native forage and 19.6% of bermudagrass populations would be considered deficient in Mn for beef cattle (Table 1). Most of the bermudagrass population Mn concentrations (57.3%) ranged from 48 to 116 ppm Mn. Approximately 45% of the native forage Mn concentrations fell within this range. Generally, levels of 100 ppm Mn are not considered to be detrimental to animal production. Little is known about the interaction of Mn with other trace elements, but levels of as much as 1,000 ppm have had no adverse effects on cattle.

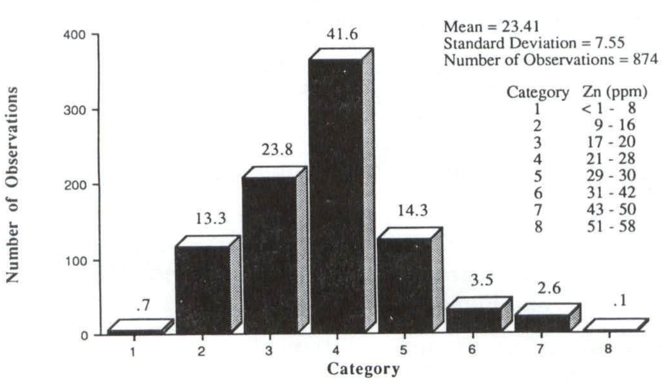

Figure 13. Number of observations within each category of Zn concentration (ppm dry matter) for bermudagrass forage. Number above column is the percentage of the population within that category.

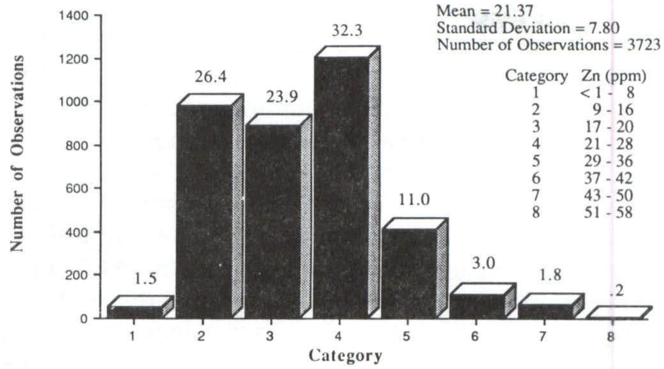

Figure 14. Number of observations within each category of Zn concentration (ppm dry matter) for native forage. Number above column is the percentage of the population within that category.

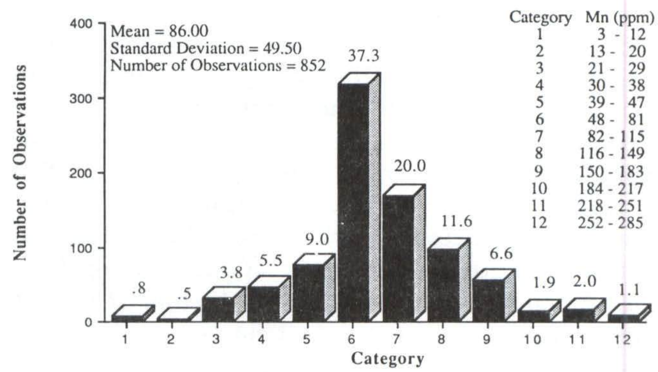

Figure 15. Number of observations within each category of Mn concentration (ppm dry matter) for bermudagrass forage. Number above column is the percentage of the population within that category.

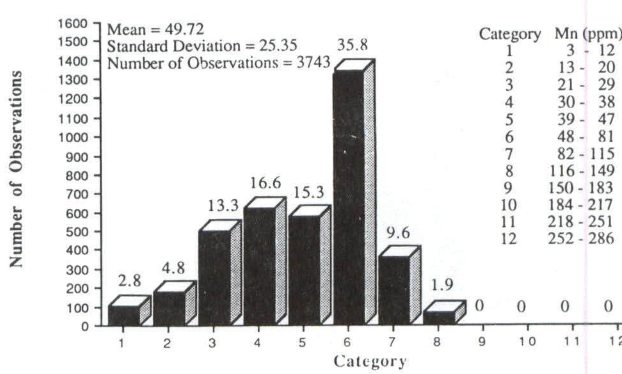

Figure 16. Number of observations within each category of Mn concentration (ppm dry matter) for native forage. Number above column is the percentage of the population within that category.

Iron concentrations were generally adequate for beef cattle; 9.1% of bermudagrass and 3.3% of native forage Fe concentrations were categorized as deficient, according to NRC recommendations (Figs. 17 and 18). A numerically greater percentage of the native population Fe concentrations (34.9%) are excessive (> 200 ppm) compared with the bermudagrass population (9.1%). Approximately 80 and 62% of the forage Fe concentrations ranged from 50 to 208 ppm for bermudagrass and native forage, respectively. Because most of native and bermudagrass forages contain adequate to high levels of Fe, additional Fe supplementation is not recommended because of its negative interaction with other minerals that are likely to be marginal to deficient in the forage. Iron supplements should be provided to grazing cattle in Texas only in specific situations for which an Fe deficiency is identified.

The data presented in this report suggest a widespread occurrence of deficient levels of forage P, Cu, and Zn for beef cattle grazing Texas forages. In contrast S, Fe, and Mn concentrations were at levels considered to be adequate to excessive in these forages. Mineral concentration distribution of the native forage and bermudagrass populations indicate important differences for cattle grazing these forages. A numerically greater percentage of native forage K, P, Cu, and Zn concentrations (38, 88, 45, and 52%) were categorized as deficient for all classes of beef cattle compared with bermudagrass (1.5, 21, 19, and 38%). These data indicate that mineral supplements for cattle grazing native or bermudagrass forage require different formulations for optimal production.

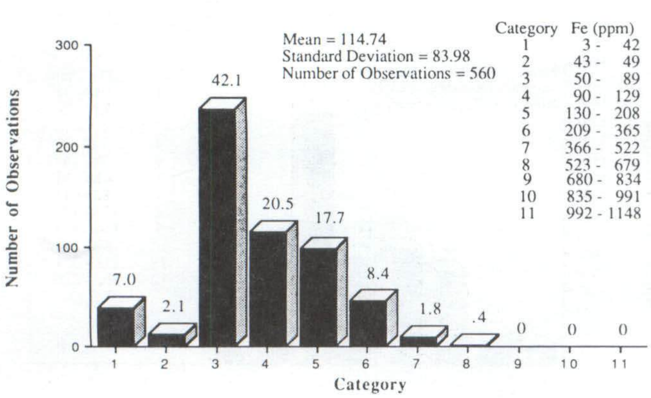

Figure 17. Number of observations within each category of Fe concentration (ppm dry matter) for bermudagrass forage. Number above column is the percentage of the population within that category.

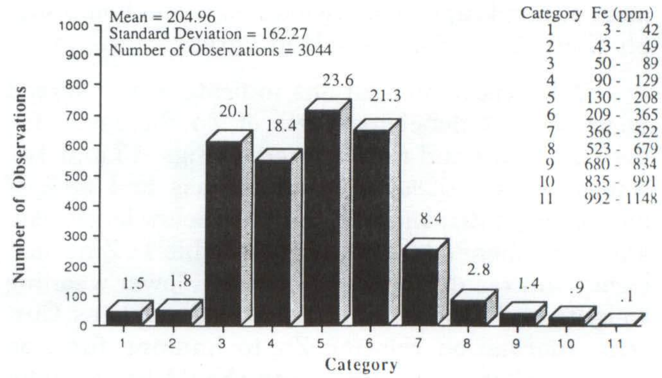

Figure 18. Number of observations within each category of Fe concentration (ppm dry matter) for native forage. Number above column is the percentage of the population within that category.

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