Mineral Composition of Bermudagrass and Native Forages in Texas

L. W. Greene*
Texas A&M University Agricultural Research and Extension Center, Amarillo and Division of Agriculture, West Texas A&M University, Canyon
P. F. Hardt
Hi Pro Feeds, Friona, TX
D. B. Herd
Department of Animal Science, Texas A&M University, Texas Agricultural Extension Service, College Station

ABSTRACT

This project was conducted to compile mineral composition of Bermudagrass and native forage samples analyzed by the Texas A&M University Extension Soil, Water and Forage Testing Laboratory.

Approximately 12,000 forage samples originating from either Bermudagrass or native pastures over a five year period were analyzed for potassium (K), calcium (Ca), phosphorus (P), magnesium (Mg), sulfur (S), copper (Cu), zinc (Zn), manganese (Mn) and iron (Fe) content. Fertilization and other forage management practices pertaining to the samples are not known. The data suggest a widespread occurrence of deficient levels of plant phosphorus, copper and zinc for beef cattle grazing Texas forages. Forage K, Ca, P, Mg, S, Cu, Zn, Mn and Fe averaged 1.5 and 0.91%; 0.43 and 0.48%; 0.21 and 0.10%; 0.17 and 0.12%; 0.34 and 0.13%; 6.4 and 5.0 ppm; 23.4 and 21.4 ppm; 86 and 49.7 ppm; and 114 and 205 ppm for Bermudagrass and native forages, respectively. Mineral concentration distribution of the native and Bermudagrass forages indicate important differences for grazing cattle. A numerically greater percentage of native forage K, P, Cu and Zn concentrations were categorized as deficient for all classes of beef cattle compared to Bermudagrass forage (38, 88, 45 and 52 vs. 1.5, 21, 19 and 38%, respectively). These data indicate major differences in forage mineral concentration between Bermudagrass and native forages.

KEYWORDS: Bermudagrass, Native Forage, Mineral Composition, Beef Cattle, Texas

Forage production is an important component of agriculture in Texas and is evidenced by the fact that 43.6% of land use in Texas is devoted to grazing lands and/or hay production (Census of Agriculture, 1992). Forages used for grazing are harvested by animals throughout their growth cycle which results in a tremendous variation of forage nutrient supply. These variations are due to time of growing season, live or dead vegetation, plant phenology, fertility and many environmental factors (Greene, 1997). These variations result in significant fluctuations in nutrient supply. As a consequence, nutrient

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supplementation of grazing livestock is a challenge to maintain optimum production efficiency. The objective of this project was to determine the mineral composition of Bermudagrass and native forages produced in Texas and discuss the variations observed with respect to grazing beef cattle requirements.

MATERIALS AND METHODS

The forage mineral concentrations utilized in this study were assembled from forage reports issued by the Texas Agricultural Extension Service Soil, Water and Forage Testing Laboratory on the campus of Texas A&M University to its clientele over a five year period. Knowledge of the forage sample is limited to that issued in the original report, and the fertilization practices and maturity management is not known. Bermudagrass cultures or species composition of the native range samples are unknown. Approximately 88% of potassium (K), calcium (Ca), phosphorus (P) and magnesium (Mg) and 43% of sulfur (S) Bermudagrass concentrations were analyzed by near infrared reflectance spectroscopy (NIRS) (ISI, 1991). Copper (Cu), zinc (Zn), manganese (Mn) and iron (Fe) in Bermudagrass and all the mineral concentrations of native forage were analyzed by the wet chemistry (WC) procedure as outlined by Parkinson et al. (1975) followed by determination by inductively coupled argon plasma emission spectrophotometry. Initial comparison between NIRS and WC techniques for estimating mean concentrations of Bermudagrass K, Ca, P, Mg and S concentrations indicated the NIRS analysis overestimated mean K, Ca, P and Mg concentrations by 7 to 15% ($P<.001$) and underestimated mean S concentrations 7% lower ($P<.001$) than that estimated by WC. Therefore, NIRS values for these minerals in Bermudagrass were adjusted to WC values based upon 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. Frequency histograms of the number of observations within a prescribed range of forage mineral concentrations are presented in Fig. 1 through 18 to provide data on the sample population. Mineral requirements for a mature, non-lactating beef cow (NRC, 1996) were used to determine breakpoints between categories where necessary to relate forage mineral concentration to animal mineral requirements. The original database 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 $\pm$ 3 standard deviations have been excluded from Fig. 1 through 18. In all cases, these observations represented less than 1.5% of the total samples. Bermudagrass pasture and Bermudagrass hay have been pooled and native pasture and native hay have been pooled. Forage mineral concentrations are presented on a dry matter basis. The TTEST procedure was used to determine differences in mean mineral concentration between forage types (SAS, 1985).

RESULTS AND DISCUSSION

For comparison between forage mineral concentration and cattle mineral requirements, Table 1 presents mineral requirements estimated for various classes of beef cattle (NRC, 1996). Bermudagrass forage had greater ($P < .0001$) mean concentrations of K, P, Mg, S, Cu, Zn and Mn than native forage (Fig. 1, 2 and 5 through 16). Native forage had greater ($P<.0001$) mean concentrations of Ca and Fe than Bermudagrass (Fig. 3, 4, 17 and

18). The greater average K, P and S concentrations of Bermudagrass compared to native forage are presumably due to forage type, soil conditions and to fertilization with these minerals in the production of Bermudagrass. The controlling factor that can potentially alter forage mineral composition more than any other practice is fertilization. Application of fertilizer to optimize plant growth and productivity also changes plant mineral composition. Most improved forages in the South have been maintained through extensive fertilization programs. The demand for minerals such as P is often higher than supplied by the soil and application of this mineral in fertilizers has increased the amount of P available for livestock consumption. This is proven due to the fact that most native, non-fertilized forages are often deficient in P.

The greater average concentration of Cu, Zn and Mn for Bermudagrass compared to 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. Soils are very different with respect to the minerals found in the soil matrix. Sandy soils often allow specific minerals to leach more easily from the growing surface than heavier clay soils. Soil acidity will also impact the availability of soil minerals for uptake by roots and subsequent translocation to plant tissues.

Table 1. Mineral requirements for various classes of grazing cattle.[a]

	Cows				
		Lactating [b]		Stocker calf [c], 200 kg	
Mineral	Non-lactating [d]	Early lactation	Late lactation	.5 kg gain	1.0 kg gain
Calcium, %	0.30	0.36	0.27	0.40	0.60
Phosphorus, %	0.18	0.24	0.19	0.22	0.32
Magnesium, %	0.12	0.20	0.12	0.10	0.10
Potassium, %	0.60	0.70	0.60	0.60	0.60
Sulfur, %	0.15	0.15	0.15	0.15	0.15
Copper, ppm	10	10	10	10	10
Zinc, ppm	30	30	30	30	30
Manganese, ppm	40	40	40	20	20
Iron, ppm	50	50	50	50	50

[a] NRC, 1996

[b] Assumes average milk production

[c] Calcium and phosphorus requirement decreases (% of DM intake) as stocker calf increases in weight and increases (% of DM intake) as rate of gain increases.

[d] Late gestation

Potassium

Approximately 90% of the Bermudagrass K concentrations ranged from .65 to 2.09%, with 1.5% deficient and 8.6% potentially excessive for mature, non-lactating beef cows (Fig. 1). In comparison, 57% of the native forage K concentrations ranged from .65 to 2.09% K, with 38% deficient and only 5.2% being excessive (Fig. 2). These data are similar to other data that shows forage K is higher in warm-season perennial forages compared to the native grasses (Mills, unpublished; Brown et al., 1988; Kappel et al., 1985). Previous data from our laboratory (Greene et al., 1987) show that stage of growth is important when predicting forage K concentrations. Actively growing (green) plant tissue is much higher in K content than 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 dormant, additional K in free choice supplements may prove advantageous. Unlike most minerals, K is excreted in the urine 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 (Greene et al., 1983). This is a much greater problem when cows graze cool-season perennial or annual forages compared to the forage types presented in this manuscript. An excessive intake of K is generally not a practical problem when cattle consume either Bermudagrass or native forages.

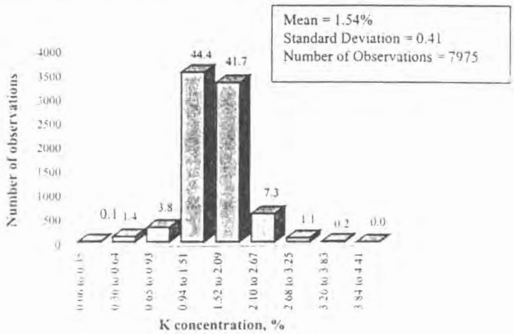

Figure 1. Number of observations within each range of potassium concentrations (% dry matter) for Bermudagrass forage.

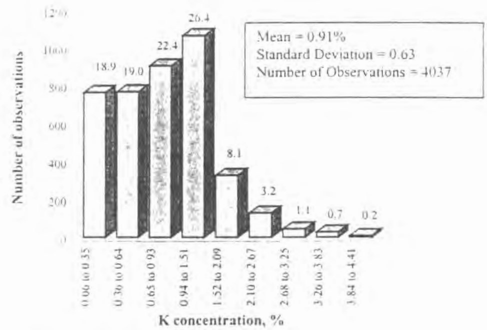

Figure 2. Number of observations within each range of potassium concentrations (% dry matter) for Native forage.

Calcium

Calcium requirement changes with level of milk production and stage of growth. Data presented in Fig. 3 and 4 show that 8.6 and 2.1 % of the Bermudagrass and native forage, respectively, was deficient in Ca for most classes of cattle. The majority of the forage Ca concentrations ranged from .31 to .66% which will be adequate for beef cattle production in most cases. The percentage of the forage population within this range was 71 and 71.8% for Bermudagrass and native forage, respectively. The growth rate of steers while grazing Bermudagrass or native forage will probably not be great enough to warrant more than .6% dietary Ca. The amount of Ca required in forage to meet grazing animal requirements depends on the relationship of Ca with other dietary minerals. Usually, metabolic disorders are more prominent when P levels are high with respect 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 Texas.

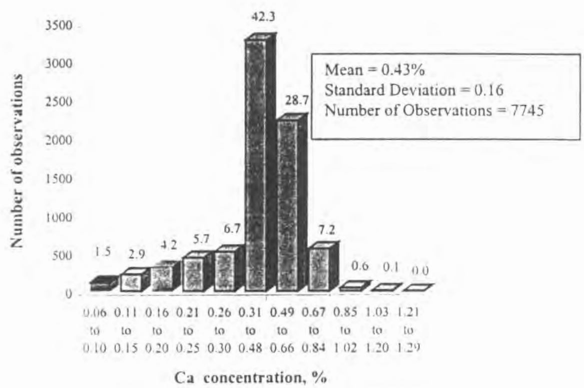

Figure 3. Number of observations within each range of calcium concentration (% of dry matter) for Bermudagrass forage.

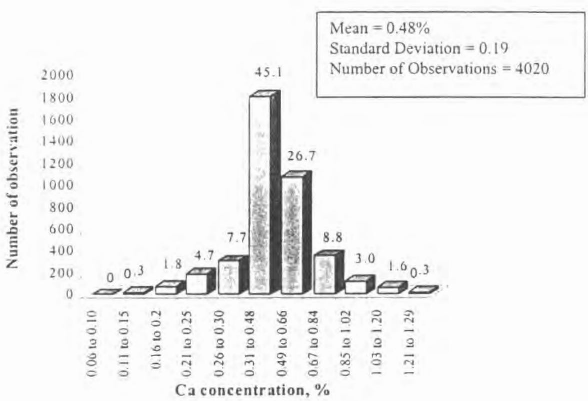

Figure 4. Number of observations within each range of calcium concentrations (% dry matter) for native forage.

Phosphorus

There was a large numerical difference between Bermudagrass and native forage in the percentage of the population deficient in P. Twenty-one percent of the Bermudagrass samples were deficient in P for grazing livestock compared to 88% of the Native samples (Fig. 5 and 6). For a lactating cow, that proportion of the population deficient in P would be approximately 65 and 96% of Bermudagrass and native forages, respectively. Common mineral supplements used throughout the south supply equal portions of Ca (12%) and P (12%), and a 1:1 percentage of Ca and P is still required in mineral supplements for many production environments. However, when cattle graze forages fertilized with P and low in available Ca (such as those reported in this manuscript), mineral supplementation programs will be more effective if the Ca P ratio is 2:1 to supply 12% Ca and 6% P. This ratio supplies a more balanced Ca and P supplement to cattle grazing P fertilized forages when Ca may be low. In the present data, approximately 74 and 8.9% of the Bermudagrass and native forage P concentrations, respectively, ranged from .17 to .30% P. Native forages are predominately deficient in P, and P must be supplied as a supplement to optimize production.

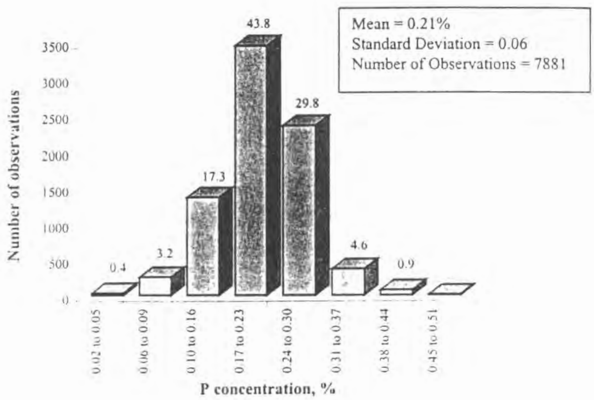

Figure 5. Number of observations within each range of phosphorus concentrations (% dry matter) for Bermudagrass forage.

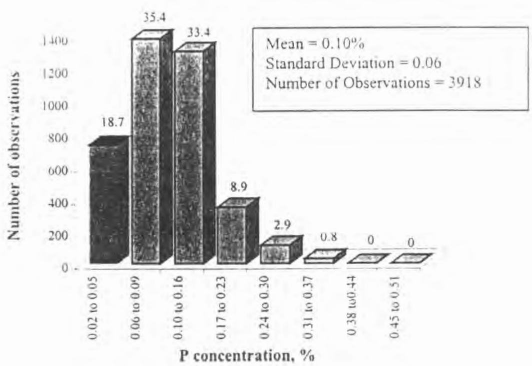

Figure 6. Number of observations within each range of phosphorus concentrations (% dry matter) for Native forage.

Magnesium

Based upon NRC (1996) recommendations, 8.2 and 49.7% of Bermudagrass (.1%) and native (2.9%) forage samples, respectively, were deficient in Mg for a mature, non-lactating cow (Fig. 7 and 8). Seventy three percent of the Bermudagrass forage Mg concentrations ranged from .14 to .22% Mg compared to 24% of the native population. The majority of native forage Mg concentrations (53%) fell within a range of .08 to .13%, lower than required by a lactating cow. However, Mg deficiency (grass tetany) is not reported to be a problem when cattle graze native pastures. Usually cattle grazing Bermudagrass pastures have an adequate Mg supply to meet the physiological needs of the cattle. It is well known that high (>2.4%) dietary K (as seen in rapidly growing winter pastures) will interfere with Mg utilization (Greene et al., 1983). Usually, dietary K in Bermudagrass and native forage is not high enough to negatively impact Mg availability in these forages. Pastures heavily fertilized with nitrogen have been identified to create a higher incidence of the grass tetany syndrome in cows during late gestation and early lactation, which is probably due to mineral imbalances in the forage. (Robinson etal., 1989).

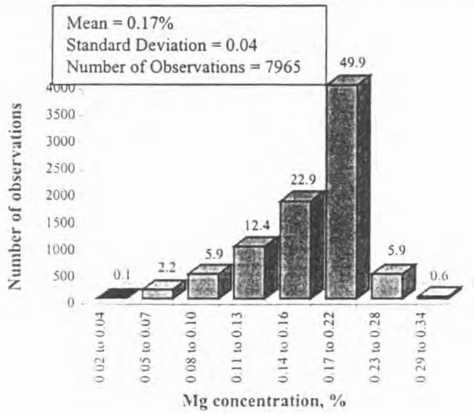

Figure 7. Number of observations within each range of magnesium concentrations (% dry matter) for Bermudagrass forage.

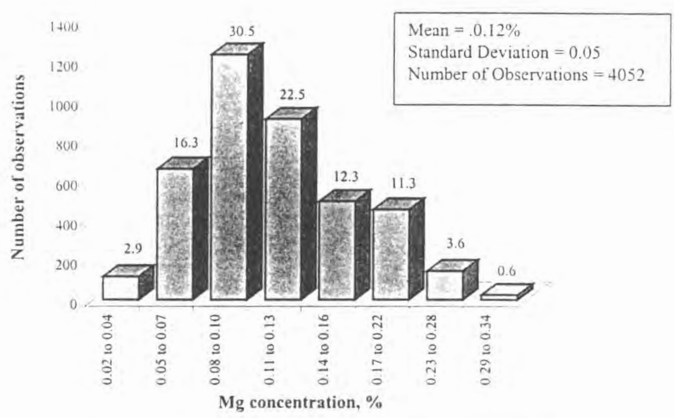

Figure 8. Number of observations within each range of magnesium concentrations (% dry matter) for Native forage.

Sulfur

No Bermudagrass forage was deficient in S compared to 58.6% of the native forage (Fig. 9 and 10). Of more importance in Bermudagrass is the proportion of samples with excessive levels of S. Fifty percent of the Bermudagrass S concentrations were at levels (.32 - .67%) that have been implicated in reducing Cu utilization and/or dry matter intake. Less than 2.3% of the native S concentrations are considered to be excessive, and S supplementation is advised when native forage is below .10% S. Sixty five percent of Bermudagrass S concentrations ranged from .20 to .43% S. The majority of the S concentrations for native forage (73%) ranged from .08 to .16% 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. In addition, many sources of water have been found to provide excess levels of S. These should be considered when evaluating total S intake.

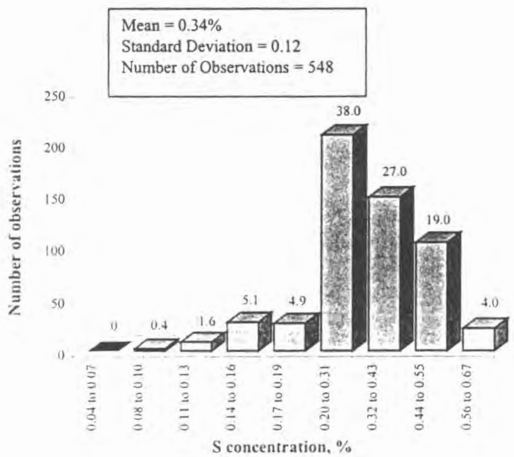

Figure 9. Number of observations within each range of sulfur concentrations (% dry matter) for Bermudagrass forage.

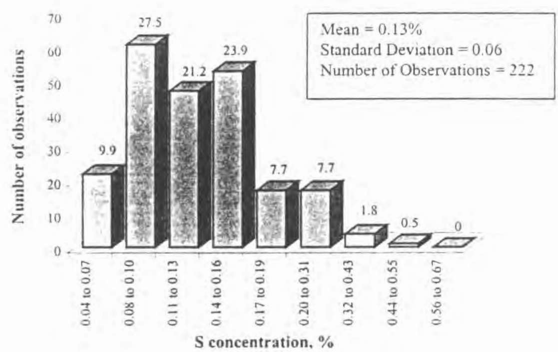

Figure 10. Number of observations within each range of sulfur concentrations (% dry matter) for native forage.

Copper

The average Cu concentration in Bermudagrass and native forages was 6.4 and 5.0 ppm, respectively. This level of Cu is less than the requirement for all classes of beef cattle. The percentage of the forage samples deficient in Cu was numerically greater for native compared to Bermudagrass forage (Fig. 11 and 12). Over 95 and 84% of the Bermudagrass and native forage Cu concentrations, respectively, were categorized as deficient for all classes of cattle. Elevated dietary Fe or S plus molybdenum (Mo) have been shown to have a dramatic reduction on Cu bioavailability (Suttle etal.,1984). Interactions of these dietary components can increase Cu requirements 1.5 to 4 fold. In the present data S is high in 50% of Bermudagrass samples, and Fe is high in 35% of native samples. Limited information is available on forage Mo concentration, but it is not uncommon to find Mo in excess in these forages. The distribution of Cu concentrations shown in Fig. 11 and 12 indicate that forage Cu levels are not adequate to maintain animal productivity in many situations. Therefore, most mineral supplementation programs should supply Cu to forage-fed animals.

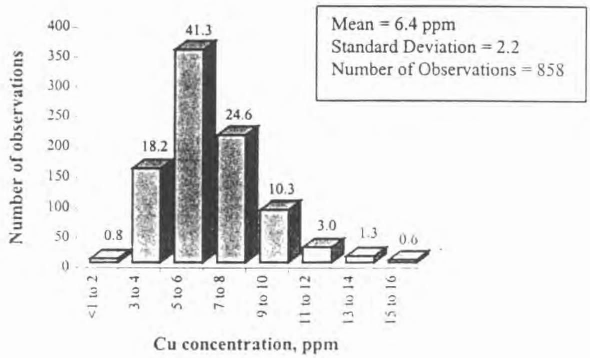

Figure 11. Number of observations within each range of copper concentrations (ppm dry matter) for Bermudagrass forage.

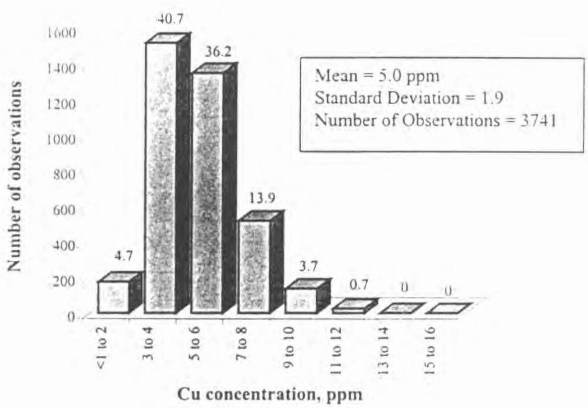

Figure 12. Number of observations within each range of copper concentrations (ppm dry matter) for native forage.

Zinc

The mean forage Zn concentrations were 23.4 and 21.4 ppm for Bermudagrass and native forage, respectively. Based on NRC (1996) requirements and data collected in this study, there is a widespread occurrence of deficient levels of Zn for cattle fed Bermudagrass and native forages (Fig.13 and 14) in Texas. Approximately 79.4 and 84.1% of Bermudagrass and native forage Zn concentrations, respectively, are below levels recommended for grazing cattle. This data is similar to that found by Corah and Dargatz (1996), Kappel et al. (1985) and Brown et al. (1988). Zinc should be a component of mineral supplements for cattle in Texas to optimize production efficiency.

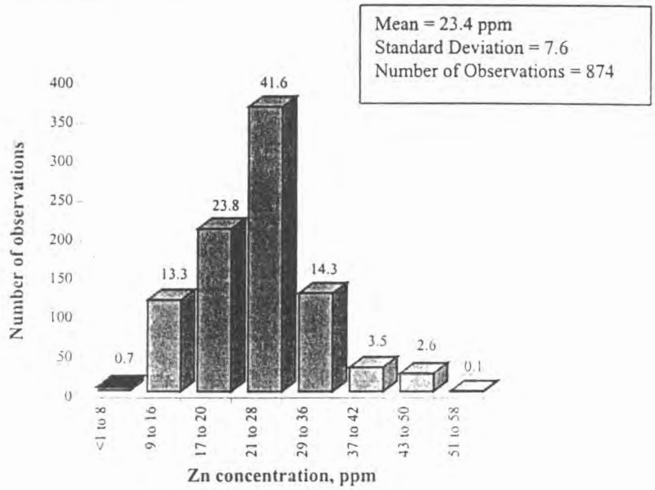

Figure 13. Number of observations within each range of zinc concentrations (ppm dry matter) for Bermudagrass forage.

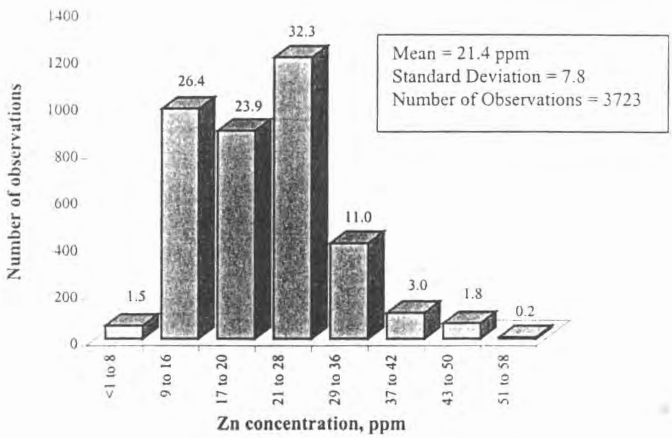

Figure 14. Number of observations within each range of zinc concentrations (ppm dry matter) for native forage.

Manganese

Both Bermudagrass and native forages exhibited a large range in Mn concentrations (3 to 285 and 3 to 149 ppm, respectively; Fig. 15 and 16). The average Mn concentrations were 86.0 and 49.7% for Bermudagrass and native forage, respectively. The majority of the Bermudagrass Mn concentrations (57.3%) ranged from 48 to 116 ppm. Approximately 45% of the native forage Mn concentrations fell within this range. Kappel et al. (1985) reported that Mn concentrations averaged 111 ppm and Corah and Dargatz (1996) reported average Mn concentrations of 125 ppm in Bermudagrass. However, Brown et al. (1988) reported Mn concentrations to be only 52 ppm in Bermudagrass forage. 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 minerals but levels of up to 1000 ppm have not had any known adverse effects on cattle.

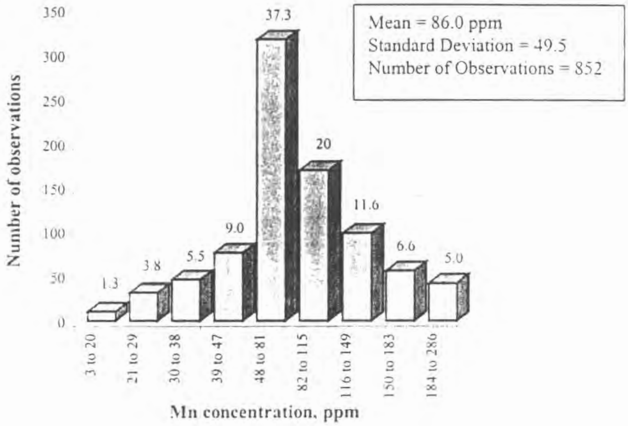

Figure 15. Number of observations within each range of Mn concentrations (ppm dry matter) for Bermudagrass forage.

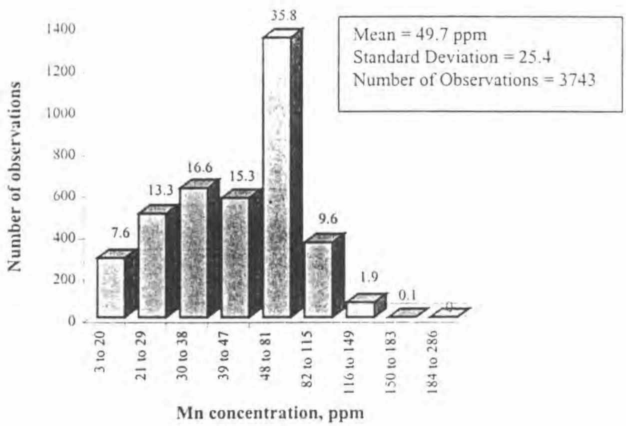

Figure 16. Number of observations within each range of Mn concentrations (ppm dry matter) for native forage.

Iron

Iron concentrations were generally adequate for beef cattle with 9.1 and 3.3% of Bermudagrass and native forage Fe concentrations categorized as deficient (Fig. 17 and 18). Approximately 80 and 62% of the Fe concentrations ranged from 50 to 208 ppm for Bermudagrass and native forage, respectively. With the majority of Bermudagrass and native forages containing adequate to high levels of Fe, additional Fe supplementation is not recommended, and is advised against due to its negative interaction with other minerals which are likely to be marginal to deficient in the forage.

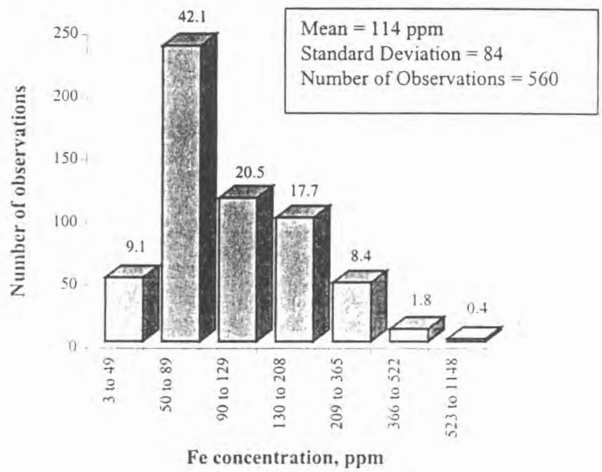

Figure 17. Number of observations within each range of Fe concentrations (ppm dry matter) for Bermudagrass forage.

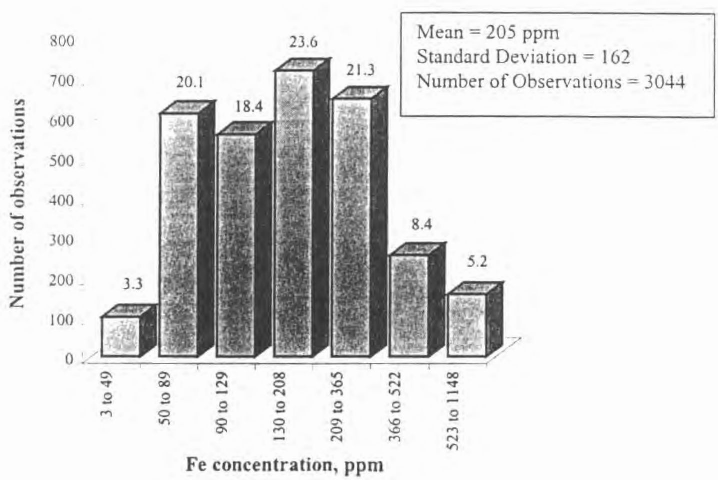

Figure 18. Number of observations within each range of Fe concentrations (ppm dry matter) for native forage.

SUMMARY AND CONCLUSIONS

The ability of forage minerals to meet grazing livestock mineral requirements depends upon the concentration of minerals in the plant and the bioavailability of these minerals. Mineral bioavailability depends upon various digestive tract interactions, mineral solubility and digestive tract pH. The digestive tract interactions are extremely important when defining animal requirements and formulating mineral supplements for grazing livestock. Many forages contain antagonists that reduce the availability of minerals. There are many mineral-mineral interactions that increase requirements such as high Mo-S diets increasing the requirement for Cu, and Mg requirement increasing as dietary K increases as previously discussed. In addition to mineral-mineral interactions, there are significant interactions between minerals and organic constituents found in plants. Organic compounds may be present that reduce the bioavailabilty of forage minerals. Many of these interactions are not clearly understood and, therefore, often makes the evaluation of forage mineral supply confusing.

Although the fertilization, management, Bermudagrass varieties, or native grass species are not known, the data presented in this report suggest a widespread occurrence of deficient levels of forage P, Cu and Zn for grazing cattle. In contrast S, Fe and Mn concentrations were at levels considered to be adequate to excessive in these forages. Mineral concentration distribution reported in this paper is confounded by many factors. It is advisable to develop a forage sampling and analysis scheme on individual farms and ranches. This will ensure a closer approximation of nutrient intake to assist in developing mineral supplementation practices specific for a particular production environment or vegetation type.

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