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MINERAL STATUS OF GRAZING BEEF CATTLE IN THE WARM CLIMATE REGION OF FLORIDA[1]

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SUMMARY

An experiment was conducted to determine the mineral status of purebred Brahman beef cattle grazing Bermuda–Bahia pastures grown on sandy, well-drained soils in Central Florida. Soil, plant, blood serum and liver tissue concentrations of calcium, potassium, sodium, magnesium, manganese and cobalt were generally adequate. Sixty-nine per cent of forages and 40% of serum samples were deficient in phosphorus. Seventy-five per cent of soils, 38% of forages and 18% of liver samples were deficient in copper. Sixty-nine per cent of forage samples were low, less than 30 ppm, in iron. All samples of forage, liver and serum were deficient in selenium. Likewise, all soil and forage samples and 47 and 88% of serum and liver samples, respectively, were deficient in zinc. Mineral elements most likely deficient and needed in supplements for grazing cattle on sandy, well-drained soils in the warm climate region of Central Florida are phosphorus, copper, selenium and zinc.

INTRODUCTION

In many tropical and warm climate regions mineral deficiencies, imbalances and excesses are a great detriment to the cattle industry (McDowell, 1976). Mineral deficiencies or imbalances in soils and forages have long been held responsible for low production and reproduction problems among Florida beef cattle. Recently nutrient status of beef cattle ranches from four soil regions of Florida was determined (Kiatoko, McDowell, Bertrand, Chapman, Pate, Martin and Conrad, 1982). Phosphorus, selenium and zinc deficiencies were present in all of the four regions studied with protein, vitamin A, potassium, magnesium, sodium, copper and cobalt deficiencies found in certain regions and related to season of the year. Mineral deficiencies or toxicities in grazing livestock can be predicted by the use of a systematic mapping survey technique or by regional reconnaissance (McDowell, 1976). The objectives of the present study were to evaluate the mineral status of soils, forages and beef cattle tissues in the sandy loam soils in the warm climate region of Central Florida.

MATERIALS AND METHODS

Liver biopsy, blood, soil and forage samples were collected from a ranch in Central Florida in May 1980. The soil (Entisol) was sandy and well drained and pastures were exclusively Bermuda grass (*Cynodon dactylon*) and Bahia grass (*Paspalum notatum*). Fertilisation of pastures consisted of 341 kg of 15 (N), 5 (P) and 10 (K) per hectare. From four separate pastures a total of 12 soil and 16 forage samples were collected. Liver and blood samples were collected from 36 Brahman cows (four to eight years old) during early pregnancy. Free choice mineral supplements containing typical macro- and microelements (except selenium) were

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available and contained the following percentages: Ca (18·0), P (6·0), NaCl (26·0), Fe (1·0), Cu (0·15), Co (0·03), Mn (0·02), Mg (0·50) and Zn (0·04).

Procedures for collection, preparation and analysis of liver biopsy, blood serum and forage samples for mineral concentrations have been described (Fick, McDowell, Miles, Wilkinson, Funk and Conrad, 1979). Liver biopsy samples (0·2 to 0·6 g dry basis) were pre-ashed on a hot plate with concentrated nitric acid and then ashed overnight in a muffle furnace at 550°C. Ash was solubilised by digestion, first with 50% nitric acid, secondly with 10% nitric acid and finally with distilled water. Calcium, magnesium, copper and zinc in serum and iron, zinc, copper and manganese in liver were analysed by flame atomic absorption spectrophotometry using a Perkin–Elmer Model 306 (Perkin–Elmer, 1973). Liver molybdenum and cobalt were determined with an atomic absorption spectrophotometer equipped with a graphite furnace and D_2 corrector (Perkin–Elmer, 1973). Serum phosphorus was determined by the colorimetric technique described by Harris and Popat (1954). Serum and liver selenium were determined by a modification of the fluorometric method (Whetter and Ullrey, 1978). Forage samples were analysed for the same minerals determined for liver and serum plus potassium and sodium as previously described.

Soil samples were collected in the same pastures where forages were sampled using a stainless steel tube at a depth of 10 to 15 cm. Soils were analysed by the method described by Mitchell and Rhue (1979) for the same minerals analysed in forage excluding selenium, cobalt and molybdenum. Soil pH was determined using a 1:2 soil-to-water ratio in a standard glass electrode and a calomel reference electrode. Soil organic matter was determined by the Walkley–Black procedure (Allison, 1965) and phosphorus with the Technicon Autoanalyzer II (Technicon Industrial Systems, 1976).

The word "critical" is used in this paper to note a concentration in forages below (or above in case of excesses) the quantity estimated by the NRC (1976) to be the requirement for cattle. Total consumption per day, not concentration in

TABLE 1

Soil mineral element concentrations (dry basis), pH and organic matter as related to critical levels[1]

Mineral	Soil concentration		Critical level[3]	% samples below critical level
	mean	S.D.[2]		
Calcium (ppm)	403·5	154·6	71	0
Phosphorus (ppm)	76·2	26·7	5	0
Potassium (ppm)	76·3	82·6	30	0
Sodium (ppm)	16·3	6·1		
Magnesium (ppm)	70·5	9·8	9·1	0
Copper (ppm)	0·63	0·55	1	75
Iron (ppm)	16·3	4·4	4·5	0
Manganese (ppm)	3·3	0·82	5	100
Zinc (ppm)	1·4	1·34	6	100
Organic matter (%)	1·6	0·34		
pH	6·3	0·35		

[1] Represents four pastures with three soil samples collected each for total of 12.
[2] Standard deviation.
[3] Breland, 1976; Warneke and Robertson, 1976; Cox and Kamprath, 1972; Blue *et al*, 1982; Gammon, 1976.

TABLE II

Forage mineral concentrations (dry basis) as related to critical levels[1]

Mineral	Forage concentration		Critical level[3]	% samples below critical level
	Mean	S.D.[2]		
Calcium (%)	0·3	0·14	0·3	43·8
Phosphorus (%)	0·22	0·05	0·25	68·8
Magnesium (%)	0·22	0·06	0·2	31·3
Potassium (%)	1·43	0·27	0·6	0
Sodium (%)	0·09	0·04	0·06	0
Cobalt (ppm)	0·12	0·04	0·1	25
Copper (ppm)	15·1	13·3	10	37·5
Iron (ppm)	29·2	12·9	30	68·8
Manganese (ppm)	66·3	25·1	30	6·2
Molybdenum (ppm)	0·2	0·02	6	0
Selenium (ppm)	0·04	0·02	0·1	100
Zinc (ppm)	18·7	6·4	30	100

[1] Represents four pastures with four samples each for total of 16.
[2] Standard deviation.
[3] McDowell and Conrad, 1977.

forage, would be used to determine the true adequacy of a mineral element. Critical animal tissue concentrations were considered to be below or above values associated with specific clinical signs as reported in the literature.

RESULTS AND DISCUSSION

Soil and forage mineral composition data are presented in Tables I and II. On the basis of ARC (1980) and NRC (1976) requirements in cattle rations for concentrations of mineral elements the forages consumed in expected quantities were deficient in phosphorus, iron, selenium and zinc. Of the 16 total forage samples analysed for phosphorus 68·8% were below the critical level (<0·25%) suggested by McDowell and Conrad (1977). However, all the soil samples analysed were above the critical level of phosphorus (>5·0 ppm) as suggested by Breland (1976). Mean pasture forage phosphorus concentrations in Florida have been reported to be low, especially during the dry season, with Becker, Henderson and Leighty (1965) reporting a decrease in level of forage phosphorus from 0·23% in April to 0·11% in July. Soil calcium averaged 403·5 ppm which was markedly higher than the range of 72 to 140 ppm reported by Breland (1976) for Florida soils. Nevertheless 43·8% of the forages provided less than the requirement of 0·3% (NRC, 1976) for grazing cattle. Mean soil magnesium was 76·2 ppm, much higher than the critical level of 9·1 ppm reported by Breland (1976). Forage magnesium averaged 0·22% which was higher than 0·18% recommended by the NRC (1976). All samples analysed for potassium were above critical concentrations in soils (30 ppm, Warncke and Robertson, 1976) and forages (0·6%, McDowell and Conrad, 1977). A recent report (Kiatoko *et al,* 1982) indicated that Central Florida forage potassium concentrations were adequate during the wet season (1·05%) but were lower (0·56%) during the dry season. All forages were adequate in sodium when compared with the NRC sodium requirement of 0·60%. Many tropical regions have reported low forage sodium concentrations (McDowell, 1976).

Generally forages were within the normal limits for molybdenum and manganese. However, all soil manganese concentrations were below the critical

level of 5·0 ppm as suggested by Gammon (1976). A relatively large percentage of forages were borderline to deficient in concentrations of iron (69%), cobalt (25%) and copper (38%). Seventy-five per cent of soil copper concentrations were likewise below the reported critical level of 1 ppm (Gammon, 1976) but none of the soil iron concentrations was below the critical level of 4·5 ppm reported by Cox and Kamprath (1972).

Forage trace elements most severely deficient were selenium and zinc with all forages containing less than the critical concentrations of 0·1 and 30 ppm respectively. All soil zinc concentrations were below the critical level of 6 ppm zinc (Blue, Jacome and Afre, 1982). In recent years zinc deficiencies have been reported in cattle with one of the earliest reports for cattle grazing forages containing 18 to 42 ppm in Guyana (Legg and Sears, 1960). Mean forage selenium of 0·04 ppm was less than one half the requirement of 0·1 ppm (NRC, 1976). Selenium deficiency as evidenced by white muscle disease in calves has been reported in the Florida locations of Branford, Gainesville and Wauchula (L. R. McDowell, pers. comm.).

Mean cattle liver and blood serum concentrations are presented in Table III. Mean serum calcium was 10·4 mg/100 ml with only 6·7% of the 30 serum samples below the critical level of 8 mg/100 ml as suggested by Cunha, Shirley, Chapman, Ammerman, Davis, Kirk and Hentges (1964). Of the total serum samples analysed for phosphorus 40% were below the critical level of 4·5 mg/100 ml suggested by Underwood (1966). Considering the low levels of forage phosphorus a higher proportion of critical cattle plasma phosphorus concentrations (<4·5 mg/100 ml) were expected. Two explanations for the relatively high serum phosphorus levels were (1) use of phosphorus in mineral supplements available to cattle and (2) less than optimum conditions for the sampling and processing of blood for phosphorus

TABLE III

Mineral concentrations of blood serum and liver as related to critical levels

Mineral	Mean[1]	S.D.[2]	Critical level[3]	% samples below critical level
Blood serum				
Calcium (mg/100 ml)	10·4	2·6	8	6·7
Phosphorus (mg/100 ml)	5·2	1·8	4·5	40
Magnesium (mg/100 ml)	2·4	0·32	2	3·3
Copper (μg/ml)	0·90	0·02	0·65	0
Selenium (μg/ml)	0·006	0·003	0·03	100
Zinc (μg/ml)	0·84	0·03	0·8	46·7
Liver (ppm, dry basis)				
Copper	228	80·5	75	17·6
Cobalt	0·44	0·21	0·05	0
Iron	384	88·7	180	11·7
Manganese	9·9	2·7	6	12·4
Molybdenum	2·76	0·56	5	0
Selenium	0·16	0·02	0·25	100
Zinc	107	27·4	84	88·2

[1] Number of observations is 30 serum and 26 liver.
[2] Standard deviation.
[3] McDowell, 1976; McDowell and Conrad, 1977.

analyses. Factors that elevate plasma minerals particularly phosphorus (Fick *et al*, 1979) including stress, exercise, haemolysis, temperature and plasma separation time were difficult to control during the experiment.

Of 26 liver samples 12% were below the critical level of 6 ppm manganese (McDowell and Conrad, 1977) which compares to 6·2 and 100% of forages and soils respectively below critical concentrations. Liver and ovaries are thought to be organs most likely to show detectable variations in manganese concentration with differing dietary manganese levels (Egan, 1975). Only 11·7% of liver iron concentrations were low (<180 ppm) in contrast to 68·8% of forages low in this element. Although one quarter of forage cobalt concentrations were deficient (<0·1 ppm) all liver cobalt levels were adequate, above the critical level of 0·05 ppm (Underwood, 1977). Large quantities of cobalt are included in Florida free choice mineral supplements further explaining high liver Co concentrations.

All serum and 82·4% of liver samples analysed for copper were above the critical levels of 0·65 μg/ml and 75 ppm respectively as suggested by McDowell and Conrad (1977). Liver copper levels are more reliable than blood levels in assessing the copper status of the animal (Doyle and Spaulding, 1978). In a previous Florida study (McDowell, Kiatoko, Bertrand, Chapman, Pate, Martin and Conrad, 1982) 36·4% of all liver samples were low (<75 ppm) in copper during the wet season and 20·2% had low concentrations during the dry season. With the exception of phosphorus and possibly cobalt, copper is the most limiting mineral for grazing cattle in tropical developing countries (McDowell, 1976).

In agreement with deficient zinc concentrations in both soils and forages 47% of the serum and 88·2% of liver samples analysed for zinc were below the critical levels of 0·8 μg/ml and 84 ppm respectively recommended by McDowell and Conrad (1977). McDowell (1976) has indicated that serum zinc concentrations are a better indicator in cattle than level of this element in hepatic tissue.

All the serum and liver selenium concentrations were below suggested critical levels of 0·03 μg/ml (Underwood, 1977) and 0·25 ppm (McDowell, 1976) respectively. Both serum and liver are reported to be good indicators of the selenium status of cattle.

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TAUX DE MINERAUX CHEZ LES BOVINS AU PATURAGE DANS LA REGION DE FLORIDE DOTÉE D'UN CLIMAT CHAUD

Résumé—Une expérience a été réalisée pour déterminer les taux minéraux de bovins Brahman paturant des prairies d'herbe des Bermudes/herbe de Bahia sur des sols sableux bien drainés du centre de la Floride. Les concentrations en calcium, potassium, sodium, magnésium, manganèse, et cobalt du sol, des plantes, du sérum sanguin et du tissu hépatique étaient généralement adéquates. Soixante neuf pour cent des fourrages et 40% des echantillons de sérum étaient déficients en phosphore. Soixante quinze pour cent des sols, 38% des fourrages, et 18% des échantillons de foie étaient déficients en cuivre. Soixante neuf pour cent des échantillons de fourrages étaient pauvres, moins de 30 ppm en fer. Tous les échantillons de fourrage, de foie et de sérum étaient déficients en selenium. De même tous les échantillons de sol, de fourrage et 47 et 88% des échantillons de sérum et de foie respectivement étaient déficients en zinc. Les éléments minéraux qui ont le plus de chances de faire défaut et dont on a le plus besoin dans les compléments pour animaux au pâturage sur les sols sableux, bien drainés dans la zone à climat chaud du centre de la Floride sont le phosphore, le cuivre, le selenium et le zinc.

ESTADO METABOLICO MINERAL DE GANADO BOVINO EN PRADERAS DE LA REGION CALUROSA DE FLORIDA

Resumen—Se llevó a cabo un experimento tendiente a determinar el estado metabólico mineral de ganado Brahman puro, pastoreando pasto Bermuda-Bahía en suelos arenosos bien drenados, en le

parte Central de Florida. Se tomaron muestras de suelo, plantas y suero sanguíneo y concentraciones en el tejido hepático de calcio, potasio, sodio, magnesio, manganeso y cobalto. El 69% de las muestras de forraje y el 40% de las muestras de suero fueron deficientes en fósforo. El setenta y cinco por ciento de suelos, el 38% de forrajes y el 18% de las muestras de tejido hepático fueron deficientes en cobre. Sesenta y nueve por ciento de las muestras de forraje tuvieron menos de treinta ppm, de hierro. Todas las muestras de forraje, tejido hepático y suero fueron deficientes en selenio. Lo mismo, todas las muestras de suelos y forraje, asi como 47 y 88% de sueros y muestras de tejido hépatico, respectivamente, fueron deficientes en zinc. Se concluye, que los elementos posiblemente más necesitados en suplementos minerales para ganado en la zona son: fósforo, cobre, selenio y zinc.

BOOK REVIEW

Animal Production and Health in the Tropics. Eds. M. R. Jainudeen and A. R. Omar. Penerbit Universiti Pertanian Malaysia, 1982. ix+470 pp.

This book is a collection of papers delivered at the first Asian–Australian Animal Science Congress held in the Universiti Pertanian Malaysia, Serdang in September, 1980. Therefore it is not surprising that the bias of the papers is towards Australia and Asia and therefore the title is somewhat misleading.

The reports of the plenary sessions contains general papers in the fields of Production, Breeding and Health whilst the specialised scientific sessions cover similar areas and a total of 70 papers are printed covering a whole gamut of subjects. Perhaps this is one of the weaknesses of the publication in that it tries to cover too many subjects and too many interests.

The Animal Health papers are useful and broad, stressing economics, management, organisation, research priorities which is probably the correct approach in this type of proceedings. Several of the authors are world authorities and the standard of presentation is high. In the nutrition and physiology sections there is a great divide between the imported 'experts' who contributed to the plenary sessions and the local whose presentation appear in the scientific session. These local papers often reflect a lack of resources (90% of non-ruminant feed is imported) and extensive lack of knowledge of basic information, e.g. nutritive value and chemical composition of local foods. However most of the papers are fairly well organised and well presented.

To sum up, these proceedings sound rather grander than they really are and consist of a hotch-potch of papers without any general theme. However there is much useful information contained in the book although the lack of an index makes it rather inaccessible. It should make a useful addition to libraries of Institutes concerned with Tropical Animal Production and Health.

A. J. Smith