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MINERAL COMPOSITION OF PLANT TISSUE, BLOOD SERUM AND MINERAL SUPLEMENTATION OF LIVESTOCK

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Mineral Composition of Plant Tissue and Blood Serum and Mineral Supplementation of Livestock on North Andros, Bahamas

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INTRODUCTION:

North Andros soils are composed of oolitic limestone sediments formed during the Pliestocene Era. Solution of the limestone by rain and sea water during the Ice Age resulted in the flat topography containing numerous sink holes and solution channels. The water table at the experimental site is about 4 feet below the soil surface and soil pH values range from 7.8 to 8.2. Typically, soils are low in phosphorus, aluminum, manganese, iron and zinc; low to medium in potassium; and medium in magnesium, copper and sodium, and extremely high in calcium. Previous information was generally lacking on mineral profiles of forages grown on similar soils (especially when the wide range in plant species and types tested on BARTAD is considered), and the resulting macro- and trace-mineral status of animals grazing the forage that was produced. Balancing the animals' needs for specific mineral elements is an extremely important determinant of livestock health and production level, and should consider the plant composition and the mineral supplementation that is provided.

Blood composition and post-mortem examinations assume particular importance in environments such as that on Andros, since the animals continually have access to high-calcium soils, and because of the possible antagonism and impairment of plant uptake of various mineral elements due to the high soil alkalinity. Although the number of plant and blood sample mineral profile analyses, which are difficult and costly to conduct, are limited, this report summarizes these results.

PROCEDURES:

Blood samples were collected periodically throughout the project. During the early part of the initial livestock projects, samples were obtained each 56 days from different groups of livestock. Since the livestock were usually moved from pasture to pasture during the early phases of the project, it was difficult to relate blood composition precisely to the type of forage being

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consumed. There were several times during the project in which abnormally high or low blood or organ (from post-mortem evaluation) trace mineral levels were observed, and specific treatments or changes in mineral supplementation practices were initiated. These are included in the following discussion.

RESULTS AND DISCUSSION:

Initial Mineral Supplementation Practices - Realizing that phosphorus and the trace minerals were the most likely to be the limiting mineral elements in the diet, initial mineral supplementation was based on providing trace-mineralized salt and mono-sodium phosphate in two separate self-feeding boxes for all animals. The initial trace mineral salt contained 0.350% zinc, 0.280% manganese, 0.175% iron, 0.007% iodine, 0.035% copper and 0.007% cobalt (all percentages were not less than stated values).

Early Blood Composition of Cattle - The first blood samples to be collected on the BARTAD livestock were taken from randomly selected beef cattle in August and October, 1974, and January, 1975. These cattle were imported in June, 1974, and through the blood sampling periods grazed primarily mixed grass-legume pastures consisting of guineagrass, green panicgrass, buffelgrass, siratro and centro in 2-9 and 3-13, and for shorter periods in the original sorghum-sudangrass plantings in 2-10, 2-11 and 2-12. The results of these blood analyses are presented in Table 1. The "standard values" presented in Table 1 for comparison were taken primarily from cattle used for dairy purposes in temperate regions. However, these values should represent normally expected averages for healthy, productive animals regardless of geographical area. In Table 1, the blood analyses are also averaged over all three sampling dates by different ages and types of cattle.

For each sampling date, the blood level for each mineral element met or exceeded the "standard value." Potassium was the element in which the actual analysis was the greatest in excess of the standard value. Magnesium blood values (average of 2.2 to 2.53 mg %) were satisfactory although the trace mineral salt did not contain even moderate levels of magnesium. As will be discussed later, there was concern regarding isolated high levels of copper in sheep blood samples, although in the case of cattle, the blood copper values can not be considered excessively high. The calcium and phosphorus values were also normal in every aspect, which was particularly interesting because of the calcium domination of the Andros soil.

Mineral profiles between different classes of cattle are also of interest (Table 1). As might be expected, lactating heifers and cows averaged slightly lower for calcium and phosphorus than did dry heifers, calves and bulls. This is due primarily to the increased "drain" of several of the mineral elements in the milk flow of lactating cows. It has also been observed in temperate areas that most of the circulating levels of mineral elements, especially phosphorus and magnesium, decline with increased cattle age. This was not observed in the blood serum data from the BARTAD cattle, and tends to support the acceptable mineral status of the different classes of BARTAD cattle.

Table 1. Blood Analyses for BARTAD Cattle by Cattle Types and Sampling Dates[a]

Item	Sampling Date			Cattle Type				Range	"Standard Values"[b]
	8/12/74	10/3/74	1/17/75	Dry Heifers	Lactating Heifers, Cows	Calves	Bulls	Low-High	
No. Samples	30	11	15	27	19	4	4		
Ca, mg %	9.2	9.3	9.7	9.6	8.9	9.4	9.9	8.6-10.6	9.3
P, mg %	6.2	6.6	6.2	6.7	5.9	7.8	5.1	4.6- 8.4	6.0
Mg, mg %	2.2	2.2	2.53	2.3	2.3	2.1	2.2	1.8- 2.4	2 2
K, meq/l.	7.2	7.5	6.7	7.3	7.0	6.9	7.1	6.3- 8.9	5.1
T. protein, g %	8.0	8.5	8.7	8.4	8.6	8.5	8.3	6.8- 9.9	7.6
Albumin, g %	2.7	3.0	3.5	3.0	3.2	3.3	3.2	1.9- 3.4	2.7
Globulin, g %	5.3	5.5	5.2	5.1	5.4	5.2	5.1	4.1- 7.6	4.8
Cu, ppm	0.9	1.1	--	1.0	1.1	1.0	1.1	0.6- 1.3	0.85
Fe, ppm	1.7	1.7	--	1.6	1.7	1.6	1.8	0.5- 2.2	1.6

[a]Calves obtained were from cattle in first shipment, primarily grazing mixed grass-legume pastures in 2-9 and 3-13.

[b]Due to questionable standard values for beef cattle in tropical areas, values for large number of dairy cows on temperate grasses and legumes are presented.

Although subsequent blood analyses were periodically conducted, those results were also within normally anticipated ranges and are not presented in this report. In addition, metabolic disorders of the type which may indicate mineral imbalances in cattle have been essentially non-existant. Probably one case of milk fever (ketosis) was observed early in the project period. Perhaps a more important indicator of the mineral status of the beef herd has been the marked increase in production level from year-to-year, and the absence of diagnosed or suggested mineral deficiencies.

Probable Selenium Deficiency - In the fall of 1975, selenium analyses were obtained on a 3.5-month-old calf which had died unexpectedly, although the calf was generally in an unthrifty condition prior to death. Liver sample analyses from the calf were 0.089 and 0.090 ppm of selenium. Normal liver values are between 0.3 and 0.9 ppm in domestic animal species, thereby suggesting a possibility of a selenium deficiency.

Plant tissue mineral profiles taken in the fall of 1974 also indicated low forage selenium content. The mineral analyses of five legumes and one grass produced on North Andros are presented in Table 2. These values are within the normal ranges expected for these species. However, in the fall of 1975, selenium, copper and molybdenum analyses were conducted on selected grasses and legumes from production pastures 2-9B and 3-10A. As indicated by the values in Table 3, selenium values ranged from 0.025 ppm to 0.033 ppm and would be considered below the critical dietary threshold level for animals, which is 0.05 ppm. Copper levels in these samples are slightly below normal levels for forage plants (11 to 30 ppm), but above levels normally considered adequate for animals. Molybdenum levels likewise appear to be adequate under most conditions to meet the dietary needs of cattle and sheep. This observation added concern for sufficient quantities of selenium in the plant tissue and in the animals' total diet. Additional selenium, in the form of sodium selenite, was added to the water for the cattle so as to provide one-half of their selenium requirement. "White muscle disease" problems were not noted through the remainder of the project term in cattle, and has not been a defined problem with sheep or goats. However, shortly after the possible problems were observed with selenium and copper, a special trace-mineralized salt was developed.

Probable Copper Toxicity - There was also a period of concern about the possibility of copper toxicity in sheep during the project. During several periods of the project there were undiagnosed sheep deaths allayed mostly to poisonous plants (primarily nightshade), malnutrition (energy deficiency), and isolated cases of heavy internal parasite burdens. Although most of the blood mineral analyses obtained on the sheep during this period were within normal ranges, copper values recorded in Table 4 and at other times tended to be higher than normal. During some of the blood sampling periods, blood serum copper levels were in the range of 1.03 to 1.85 ppm. In addition, two liver samples submitted in 1976 revealed copper levels in the lower range of those to be expected in chronic copper poisoning (above 350 ppm).

Table 2. Mineral Analysis of Five Legumes and One Grass Grown on Andros

Species	N	P	K	Ca	Mg	S	Mn	Fe	Cu	B	Al	Zn	Na
	----------%----------						----------Micrograms/gram----------						
Tinaroo Glycine	2.77	0.28	1.77	2.42	0.45	0.21	25	66	12	56	98	32	470
Siratro	3.77	0.28	1.28	1.92	0.59	0.19	73	57	12	28	58	26	266
Greenleaf Desmodium	2.76	0.27	1.10	1.83	0.37	0.18	38	45	8	35	79	36	373
Centro	2.85	0.29	1.66	2.75	0.55	0.29	45	42	18	43	108	31	600
Mesa-Sirsa Alfalfa	3.40	0.29	3.05	2.26	0.36	0.33	23	77	14	45	86	41	1003
Guineagrass (Non-irrg)	2.10	0.36	1.76	0.75	0.31	0.13	19	a	8	11	19	25	384
Guineagrass (Irrg.)	2.20	0.20	2.12	0.64	0.23	0.17	16	64	8	9	18	19	1000

[a]Value missing from analysis.

Table 3. Selenium, Copper and Molybdenum Contents (ppm) of Certain Legumes and Grasses

Species	Selenium	Copper	Molybdenum
Buffelgrass (2-9B)	0.025	9.69	0.731
Buffelgrass (3-10A)	0.030	8.07	1.145
Green Panic (2-9B)	0.025	9.50	1.060
Green Panic (3-10A)	0.033	4.94	1.385
Guineagrass (3-10A)	0.026	6.38	1.750
Siratro (2-9B)	0.024	13.87	0.456
Siratro (3-10A)	0.032	10.44	<0.125
Avg. ppm	0.028	8.98	0.95

Table 4. Blood Composition for BARTAD Sheep

Item	June, 1975		December, 1976		Oct. 1975	
	Avg.	Range Low-High	Avg.	Range Low-High	Avg.	Range Low-High
No. samples	(10)		(12)		(5)	
Ca, mg %	10.3	6.6-11.7	9.9	9.2-10.8	9.3	8.8- 9.7
P, mg %	5.3	3.3- 8.7	5.3	4.2- 7.2	7.0	6.3- 7.4
Mg, mg %	2.5	2.0- 3.9	2.7	2.2- 3.2	2.6	2.4- 2.7
K, meq/l.	5.7	5.1- 6.7	7.7	5.9- 9.4	8.4	7.5-10.0
T. protein, g %	6.6	6.2- 7.3	--	-- --	9.5	8.8- 9.9
Albumin, g %	1.48	1.2- 1.7	--	-- --	2.3	1.7- 3.2
Globulin, g %	5.16	4.6- 6.1	--	-- --	--	-- --
Cu, ppm	1.14	1.0- 1.6	1.04	0.73-1.3	1.2	0.97-1.49
Fe, ppm	2.35	1.8- 3.1	--	-- --	> 3.0	>3.0

Generally the limited number of plant tissue analyses did not indicate a copper excess, only normal values (11 to 30 ppm). However, there were instances early in the project in which fertilizer containing 75 pounds of copper sulfate per ton was applied several times rather than the intended single application of this specific fertilizer to the same pasture. The fertilizer was used due to an inavailability of recommended fertilizers with other analyses.

Sheep are naturally more sensitive than cattle to dietary copper excess, and molybdenum is involved in copper accumulation. When sheep graze pastures of normal copper content, but low in molybdenum (less than 0.1 ppm), copper accumulates in their livers. Conversely, when pasture or forage contains a normal amount of copper, but has a high molybdenum content (5 ppm or more), a poisoning with many of the clinical symptoms of copper deficiency may occur. With the exception of the siratro in 3-10A, most of the plant species sampled (buffelgrass, green panic and guineagrass) were within the normal range for molybdenum content (Table 2). Although repeated samples of siratro have not been analyzed for copper and molybdenum, pastures of approximately 85% or more of siratro have been grazed by sheep without unexplained deaths or decreased performance; which suggests that the above problems were overcome by the use of an altered mineral supplement or that the problem was only temporary.

Alterations in Mineral Supplementation Programs - The trace-mineral component of the mineral supplementation program was altered primarily due to the above-noted selenium and copper observations. Following is the salt formula used for all livestock:

Magnesium	1.5%
Zinc	0.35%
Manganese	0.28%
Iron	0.1%
Iodine	0.007%
Copper	0.1%
Cobalt	0.008%
Selenium	0.0013%
Vitamin A	15 mil I.U./200 lb. salt

Due to difficulties in procurement of salt with the above composition, individual packages of a special pre-mix were prepared and purchased for addition to 200 pounds of plain salt. The pre-mix package contained:

Magnesium	3.0 lbs	1362.0g
Zinc	0.70 lbs	317.8g
Manganese	0.56 lbs	254.2g
Iron	0.20 lbs	90.8g
Iodine	0.014 lbs	6.3g
Copper	0.02 lbs	9.1g
Cobalt	0.016 lbs	7.3g
Selenium	0.0026 lbs	1.2g
Vitamin A	15 mil. I.U.	

It is likely that the problems which were observed with the trace minerals were mostly temporary and will not continue to be of concern. It is also quite likely that the special trace mineral supplementation program will not have to be continued. However, it is suggested that periodic monitoring be continued on the mineral composition of plant tissue and blood serum, and that in the event of any appreciable number of unexplained deaths or poor performance, liver and other organ analyses should be obtained.

SUMMARY:

As a part of the livestock-forage projects, mineral profiles on blood serum, animal organs (obtained in post-mortem evaluations) and plant tissue were obtained and used to determine mineral status of the livestock and the mineral supplementation program. Within the first six months after cattle arrived on the project, blood serum mineral composition was within normal ranges for all mineral elements.

Forage analyses indicated, and liver tissue analysis from a calf which had died confirmed, that there was a selenium deficiency. Sheep blood serum copper levels also indicated a copper toxicity with resulting isolated cases of sheep deaths. The trace mineral salt mixture was changed to consider these two possibilities.

However, performance has continually increased, and health problems which were generally infrequent since the start of the livestock phase (particularly with cattle) have lessened. It is strongly recommended that the closest possible relationship and liason be maintained by BARTAD personnel with veterinarians from the Ministry of Agriculture and Fisheries and with a U. S. diagnostic laboratory, and that periodic plant tissue, blood and organ monitoring be continued.