Mineral status of cows and its relationship with the soil-plant system in a dairy unit of the Eastern region of Cuba

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The mineral status of cows and its relationship with the soil-pasture system in a dairy unit of the Eastern region of Cuba was studied. For soil analysis, Na, K, Mg, Ca and P contents were determined in the different animal feed production areas. The chemical composition of pastures was established and blood samples were taken to 10 % of the herd for analyzing their macro and microelement composition. The mineral content of soils varied regarding the agroproductive system where animals grazed. Pastures presented CP contents lower than those reported for the species. Cows showed severe Cu and Zn deficiencies, below the contents considered as normal. The Ca/P relationship was not adequate. It is concluded that the productive systems under study show mineral deficiencies. The use of correction mineral formulas is recommended.

Key words: *minerals, soil, pasture, blood, cows*

Minerals play a fundamental function in the metabolic and physiological processes carried out in live organisms. Their deficiencies have great repercussion on the productive and reproductive performance in the majority of the species of agricultural interest. Trace elements act as cofactors, enzymatic activators or stabilizers of the secondary molecular structure. Macroelements are part of the main support organs and are responsible for the maintenance of the electrolytic balance in the body fluids, according to Morgen (1980).

In studies realized during 1997 and 1999 by the Center for Animal Research and Improvement (CIMA), it was reported that in 240 herds from 38 livestock production enterprises throughout the country, there were simple or multiple deficiencies of macro and microelements with the consequent worsening of the productive and reproductive indicators of the bovine female and Gutiérrez *et al*. (2006) reported phosphorus and microelement deficiencies in various livestock production enterprises in Pinar del Río and Havana provinces.

From these backgrounds this study was developed with the objective of identifying the mineral status and its relationship with the soil-pasture-animal system in a dairy unit of the Eastern region of Cuba.

Materials and Methods

The experiment was conducted in areas of the dairy unit twelve, belonging to the Farm "Veguitas", in the Livestock Production Enterprise "Cuenca Lechera de Las Tunas". This unit is placed within the national system of school dairy units where the model of tropical dairy unit of Martínez (2000) is assessed. The total area of the dairy unit is of 134.2 hectares.

Pastures and forages are the feeding basis of the dairy unit constituting the main voluminous feed of the animal diet: *Pennisetum purpureum* cv. Cuba CT-115 (26.8 ha), *Panicum maximum* (guinea grass, 3 ha), Brizanta cv. mulato (3 ha), *Leucaena leucocephala*, associated in 100 % of the area, with a population density of 6 000 plants/ha (5 ha).

The highest pasture population of the livestock production system is integrated by natural pastures (80.4 ha). The structure of the natural pastures was: *Sporobolus indicus*, *Dichanthium annulatum* and *Paspalum notatum*.

The unit also has a forage area integrated by *Pennisetum purpureum* cv. Cuba CT- 169 (2 ha) and sugar cane (*Saccharum officinarum*, 1 ha), as well a forested area integrated by trees as albizia (*Albizia lebbeck* 2 ha). The livestock production system has 25 years of exploitation on a sialitic brown soil without irrigation or fertilization.

The herd of the productive unit is formed by 136 dairy cows of different blood gradations with Holstein, Zebu, Criollo and Brown Swiss cattle averaging 460 kg LW.

The chemical composition of the soil, pastures and blood serum were determined according to AOAC (1995).

Sampling procedures. Soil testing pits were made for obtaining samples where the above mentioned plants were sown. For that, cylinders 20 cm long were used and introduced in the soil with the aid of a slight hit in their upper part. Samples were scattered on a cement surface. They were dried and their mineral (Na, K, Mg, Ca and P) composition was determined.

Pastures. For taking the samples three samplings were carried out in the stage by the method of Haydock and Shaw (1975) while for Leucaena, browsing of 15 plants (small, medium and large) was simulated, in each row. The chemical composition was determined according to AOAC (1995).

Blood. Samples were taken to 10 % of the herd (15 cows) for the clinical analysis and of macro and microelements. Samples were obtained through "California" needles for extracting serum and plasma and for determining mineral composition.

Minerals were determined by atomic absorption spectroscopy, in British SP-9 Pey Unicam equipment. Phosphorus was analyzed by Amaral (1972).

Statistical analysis. For the statistical analysis of data the SPSS statistical system for Windows (Visauta 1998) was used. Mean values were compared by Duncan's (1955) multiple range test.

Results and Discussion

Table 1 shows the mineral contents of the soil in the five productive systems of the dairy unit (guinea grass, silvopastoral, natural pastures, *P. purpureum* cv. CT-115 and forested area).

Sodium content was different in the evaluated productive systems. In the soil of the forested area was higher ($P < 0.01$) regarding the remaining systems, while where the natural pastures, *P. purpureum* cv. Cuba CT-115 and the forested area were found, calcium content was higher ($P < 0.01$) regarding those where guinea grass and the silvopastoral system a were present, without differences for these latter productive systems.

Potassium and magnesium content did not differ between the different systems integrating the productive unit.

The highest contents of phosphorus were obtained in the soil with *Pennisetum purpureum* cv. Cuba CT-115 respecting the remaining systems. Possibly, this could be due to the high standard error of 49.64 for this mineral. This indicates the high variability of this inorganic compound in the system. The highest content of this element in the soil of the forested area could have its explanation in the consecutive litter accumulation and in the absence of nutrient extraction in this system, aspects that must be considered in future studies. The contents in this mineral varied between 25.50 and 274.50 ppm. The Ca/P relationship of 2:1 was not maintained in any of the soil areas evaluated.

From the results it can be inferred that the variability in the soil nutrient contents could be due, among other factors, to feces and urine deposition in the grassland that produce effects on the nutrient dynamics in the soil, owing to the way of decomposition of these excretions and to the way in which the release of their nutrient contents is produced (Crespo *et al*. 2009). In cow dung, the elements or nutrients are gradually turned into assimilable forms, as microorganisms attack the organic matter of the soil decomposing it, while in urination, the nutrients, especially N and K, are shown in a quickly assimilable way by the plants (Nennich *et al*. 2006). It has been demonstrated that phosphorus is returned, mainly, by feces, where it is slowly assimilated by plants. In urine, this element is found in insignificant amounts, with poor effect in the soil and pasture (Clark *et al*. 2010). It can be also pointed out that the presence of litter in the system can also have its influence on the variation of the soil nutrients. Crespo and Fraga (2002) demonstrated that the individual litter production of tree plants shows normally high variability. This seems to have influenced on the higher nutrient contents in the soils of the forested system.

The chemical composition of pasture is shown in table 2. Leucaena presented high CP contents regarding the remaining plants of the system which is logical considering that it is a legume. However, its contents are below those reported by Marrero (1994) and Galindo *et al*. (2007 and 2009). Grasses of the system also exhibited low protein values respecting others reported previously by different researchers.

The highest nutrient content in Leucaena has been also indicated by Jordán (2009) in studies conducted on this matter. Alonso (2003) on demonstrating the factors involved in biomass production in silvopastoral systems indicated the nutritional advantages of legumes compared to grasses. Gutiérrez *et al*. (2004) measured consumption and digestibility of nutrients from pastures in animals having access to silvopastoral systems with Leucaena protein banks. Results from these authors favored these latter, regarding to what was found in animals without access to the protein banks. This is mainly given by the high CP content of this plant.

Concerning *Pennisetum purpureum* cv. Cuba CT-115, Martínez (2000) reported CP values between

Table 1. Soil mineral contents of the farm "Veguitas"

Pastures	Na, cmol/kg	K, cmol/kg	Ca, cmol/kg	Mg, cmol/kg	P, ppm	Ca/Mg
Guinea grass	0.08[a]	0.14	16.83[a]	6.52	36.83[a]	2.58
Silvopastoral system	0.09[a]	0.13	11.83[a]	8.25	25.50[a]	1.43
Natural pastures	0.15[a]	0.16	23.75[b]	10.07	57.33[a]	2.36
P. purpureum CT-115	0.17[a]	0.08	25.58[b]	7.58	174.5[ab]	3.37
Forested area	0.28[b]	0.17	27.83[b]	8.42	274.50[b]	3.31
SE ±	0.04	0.05	1.91	0.95	49.64	
	$P < 0.01$		$P < 0.01$		$P < 0.01$	

[ab]Means with different letters within the same column differ at $P < 0.05$ (Duncan 1955)

Table 2 Chemical composition of the different pastures of the dairy unit, %

Pastures	DM	CP	Ash	Ca	P	Ca/P
Guinea grass	93.34±0.29	5.45±0.05	12.18±0.33	0.61±0.02	0.19±0.02	3.21
Mulato grass	94.02±1.47	6.20±0.17	12.17±0.32	0.22±0.05	0.19±0.03	1.15
Natural pastures	94.48±0.30	4.90±0.13	12.68±0.45	0.49±0.09	0.13±0.04	3.76
CT-115	93.06±0.10	6.43±0.32	10.34±0.12	0.52±0.05	0.27±0.03	1.92
Leucaena	92.84±0.34	21.09±1.46	12.60±0.22	1.05±0.16	0.30±0.04	3.50

9.5 and 10.8 % DM. Likewise, Valenciaga (2007) also obtained CP contents of 7.78 % for plantations of 140 d of regrowth, in a red ferrallitic soil without irrigation or fertilization. This author emphasized on the observations of Herrera *et al*. (2002) about the fact that the changes in the chemical composition of this cultivable variety are not so marked as in other tropical grasses that can be related to its high regrowth capacity.

The relatively low protein content (N x 6.25) of the plants in the studied unit was verified from the macroscopic point of view by leaf chlorosis, probably due to changes in the chlorophyll contents. This effect has been indicated by Herrera (2009).

For the phosphorus, the values shown by guinea grass, mulato grass and the mixture of natural pastures were below the critical level established (0.25 %). Respecting Ca, mulato grass was the pasture registering values below 0.30 %, considered as critical for this plant in the pastures. It is important to indicate that the phosphorus content in the introduced grass species, in general, was higher to the mean obtained by Fajardo (2009) and Gutiérrez (2010) for pastures in Cuba.

The nutrient deficiencies found in the natural pastures coincide with Fajardo (2009), García (2009) and Gutiérrez (2010) who conducted studies on the mineral status in the Western, Central and Eastern regions of Cuba. In that respect, Garmendía (2007) states that in the tropical environment there are climatic and soil restrictions that impose severe nutritional restrictions to the natural pastures developed over them.

Results obtained could determine, in the majority of the cases, poor supply of forage biomass, associated to the scarce nutrition supply. Undoubtedly, this will lead to a deficient animal response. In that respect, in the studied unit, the conception rate was below 45 %, while age, weight at first service and calving were much below the values considered efficient for maintaining a productive livestock production.

Table 3 shows the mineral composition of the blood serum of cows. There are marked mineral deficiencies as important as Cu and Zn. All animals presented contents of these minerals below the critical limit. For Cu was 11.0 µmol/L and, in the particular case of Zn, was 12.2 µmol/L.

These minerals are known as essential for animals, although they are required in small amounts. Zn is an essential component of carbonic anhydrase, enzyme that plays an important function in the acid basic balance and in the CO_2 release in the gastric mucosa. Its deficiency in blood can manifest slight diminution in the hepatic, kidney, cardiac and muscular tissues and a more intense decrease in the pancreas, affecting animal consumption.

Copper is involved in the formation of young erythrocytes, but not in hemoglobin concentration. It participates in iron absorption, in the osteogenesis; in protective functions, in hair pigmentation and keratinization (Gutiérrez 2010 and Gutiérrez *et al*. 2013). It is a component of the oxidase cytochrome, ceruloplasmin, oxidase galactose and uricase. Anemia is a general symptom of Cu deficiency. Its blood deficiency provokes high iron levels and low copper levels in the liver and this is manifested when pastures are poor in this mineral. Mg and P levels in blood were normal. However, copper was found below the critical threshold limit an aspect that is necessary to consider.

In the majority of the animals the Ca/P of 2:1 was not fulfilled for maintaining the metabolic processes under normal conditions.

In the case of copper, there are numerous studies indicating deficiencies of this microelement related to the concentrations in pastures. Different reference ranges has been reported for plasmatic Cu in bovines. Pavlata *et al*. (2000) suggested values between 12.6 and 18.9 µmol/L, while Radostitis *et al*. (2000) recommended figures between 11 and 19.8 µmol/L. These latter authors stated that Cu levels lower than 7.85 µmol/L in blood serum are related to normal Cu values in liver.

Blood level can be affected according to Arthington (2003), by two main causes: feed consumption, with low contents of the mineral in question or the antagonic effect of other minerals interfering in its metabolism.

In this study, the causes of low serum levels seem to be related to the low concentrations of this mineral in the pastures. It must be pointed out that phosphorus concentrations in serum did not correspond with the levels in the pastures. This corroborates what was suggested by Gutiérrez *et al*. (1986) who demonstrated that under grazing conditions the phosphorus levels in serum are not the most suitable for showing the status of this mineral in the soil-plant-animal system.

In the case of zinc that showed threshold levels, it must be stressed that in bovines the deficiency of this mineral produces growth delays, hair discoloration, alopecia, parakeratosis (hardening and open skin

Table 3. Mineral contents of blood serum of cow of the "Veguitas" dairy unit 12

No. of cows	Cu, µmol/L	Zn, µmol/L	Ca, mmol/L	Mg, mmol/L	P, mmol/L	Ca/P
1	1.17	3.31	3.69	2.36	2.24	(1.64:1)
2	1.28	2.52	3.11	1.28	1.77	(1.76:1)
3	1.11	4.24	3.04	1.67	1.77	(1.72:1)
4	1.20	2.58	3.93	1.87	1.77	2.22:1
5	0.26	1.69	3.60	1.86	1.88	(1.91:1)
6	0.87	2.38	3.59	2.56	1.77	2.03:1
7	0.60	2.16	3.92	0.72	2.24	(1.65:1)
8	0.35	3.44	2.43	1.97	1.77	(1.38:1)
9	0.96	2.00	4.68	1.75	1.77	2.65:1
10	1.44	3.26	3.59	2.61	1.77	2.09:1
11	1.00	1.50	3.51	1.95	1.88	(1.86:1)
12	0.89	2.03	3.48	1.86	2.12	(1.64:1)
13	0.90	2.29	3.50	1.58	1.77	(1.98:1)
14	0.40	0.90	4.95	1.85	2.00	2.47:1
15	1.34	1.73	3.45	1.92	1.27	2.73:1
Mean	0.92	2.5	3.63	1.85	1.85	(1.96:1)
Critical limit	11.0 µmol/L	12.2 µmol/L	2 mmol/L	0.78 mmol/L	1.6 mmol/L	

lesions) in ears, neck, snout, scrotum and the back of legs; also of stiff walking and tarsus and metatarsus tumefaction (Mufarrege 2001 cited by Gutiérrez y Savón 2006).

These authors indicated that Zn deficiency leads to a dysfunction of the immune system, an aspect that predisposes the animal to undergo diseases. From the reproductive point of view, estrus abnormalities, dystocia increase and placentary retention. In males, there is decrease of testicular size and libido (Patterson and Engle 2005). In sheep, Zn deficiency in the last gestation months involves fetus loss (Mufarrege 2001 cited by Gutiérrez y Savón 2006).

It is concluded that the productive systems evaluated present mineral deficiencies. Considering this condition, the use of correction mineral formulas, as well as soil improvement of the productive unit, is recommended.

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