A STUDY ON NUTRITIONAL STATUS OF MACRO MINERALS OF CATTLE IN JAVA IN INDONESIA

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Summary

Nutritional status of cattle in Java in Indonesia was investigated by evaluating P, Ca, Mg, K and Na concentrations in forage and plasma inorganic phosphorus (Pi), Ca and Mg, hematocrit and hemoglobin concentrations of cattle during both rainy and dry seasons in 1988. Investigations were conducted at Jonggol (West Java), Malang (East Java) and Majokerto (East Java).

Low P content in forage averaging 0.11% on a dry matter basis, high Ca:P ratio in forage in the rainy season (7.7:1) and low plasma Pi concentrations averaging 4.71mg/dl were observed in Jonggol. In all three places, Ca content in forages was higher than the requirement according to the NRC standard and plasma Ca concentrations were above the critical level.

During the rainy season forty percent of cattle in Malang and Majokerto showed plasma Mg concentrations below 2mg/dl in spite of normal Mg and K content in forage. Forage samples from each place showed a wide variety in Na content, and Na content of two thirds of forage samples was lower than the requirement according to the NRC standard. Hematocrit and hemoglobin concentrations in Malang and Majokerto showed higher values than the normal range.
(Key Words: Java in Indonesia, Cattle, Forage P, Ca, Mg, K and Na, Plasma Pi, Ca and Mg, Hematocrit, Hemoglobin)

Introduction

Cattle feeding in tropical Asia depend largely on native grasses and agricultural by-products such as leaves and stems of crops. Recently some investigations have indicated that mineral deficiencies in forages occurred in some places in tropical Asia. Vijchulata et al. (1983) observed that P, Ca and Na were likely to be deficient in forages from Central Thailand. Hayashi et al. (1985) reported that P, Ca, Mg and K content in forages from Medan in Smatra was lower than the requirement for cattle. However, available information concerning the mineral status of cattle in this area is limited and the relationship between mineral concentrations in farages and mineral status of cattle is still obscure. In the present study, the nutritional status of cattle in Java in Indonesia was examined by evaluating macro mineral concentrations in forage and blood components.

Materials and Methods

Location and Season for Sample Collection

Investigations were conducted at Jonggol, Malang and Mojokerto in January (mid rainy season) and August (late dry season) in 1988. Jonggol is located in Western Java and samples were collected at the experiment station of Bogor Agricultural University located on a hill 150m above sea level. The annual rainfall measured in 1975 in this area was 3200mm and the average monthly rainfall was 250-400mm from September to May and 100-150mm from June to August. Samples were collected from a herd of thirty cattle which were grazed in the native grassland in the morning and fed with chopped improved grass ad libitum during the rest of the day. No mineral supplementation was done.

Malang and Mojokerto are located in Eastern Java. Sample collection was made at slaughter houses and farms. Malang is located in a basin 400m above sea level and Mojokerto is in a plain 50m above sea level. The annual rainfall measured in 1955 in Pasuruan which is located near Malang and Mojokerto was 1285mm and the average

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monthly rainfall was 100-300mm from December to May and below 100mm from June to November. Each farm was raising one or two cattle which were fed with chopped native grass and leaves and stems of crops or tethered in the native grassland.

Blood Collection

A hundred bulls and 38 cows consisted of 123 Ongole, 6 Bali, 6 crossbreeds of OngolexBali, OngolexMadura and MaduraxBali were investigated. The ages of cattle, judged by dentition, were above one year. Blood samples were collected from the jugular vein of cattle in Jonggol and the jugular artery of cattle slaughtered in Malang and Mojokerto. Samples were heparinized immediately after collection and blood plasma was prepared by centrifugation at 3000rpm for 15-30 minutes. Plasma and whole blood samples were put in clean polypropylene vessels and frozen by dry ice.

Feed Collection

The species of diet samples were presented in table 1. In Jonggol, samples of native grass were collected from 2 points in the pasture where cattle were actually grazing and samples of improved grass were collected from 2 points in meadows. The samples from each point were categorized by species and offered for analysis. Forage samples in Malang and Mojokerto were taken from 3 or 4 farms in villages where the cattle used for investigation had been raised. The samples of native grass were collected from grassland where cattle were tethered. The samples of leaves and stems of crops and chopped native grass were taken from feed storehouses on farms. The samples from each farm were categorized by species and offered

TABLE 1. SPECIES AND MINERAL CONCENTRATIONS OF FORAGE SAMPLES FROM THREE PLACES IN INDONESIA

Place	Season	Species	Number of samples	Phosphorus	Calcium	Magnesium	Potassium	Sodium
				% on dry matter basis				
Jonggol	rainy	*Cynodon dactylon*	2	0.096	1.16	0.20	1.50	0.012
		Imperata cylindrica	2	0.068	0.74	0.11	0.92	0.010
		Oplismenus undalatifolius	2	0.096	0.91	0.18	1.57	0.009
		Paspalum dilatatum	2	0.144	0.54	0.25	1.76	0.007
		Setaria sphacelata	1	0.166	0.78	0.26	1.76	1.19
	dry	*Cynodon dactylon*	1	0.128	0.53	0.19	1.55	0.013
		Imperata cylindrica	1	0.080	0.61	0.10	1.22	0.010
		Setaria sphacelata	2	0.156	0.65	0.26	1.92	0.995
Malang	rainy	corn stover	2	0.318	0.53	0.35	2.07	0.015
		Cynodon dactylon	2	0.238	0.99	0.35	2.03	0.024
		sweet potato vine	1	0.306	2.31	0.47	2.46	0.107
		chopped native grass[a]	2	0.269	0.59	0.22	2.30	0.110
	dry	corn stover	1	0.350	0.34	0.33	2.40	0.026
		rice straw	2	0.100	0.27	0.21	1.74	0.129
		sugar cane leaf	2	0.229	0.45	0.22	2.13	0.020
		chopped native grass[a]	3	0.208	0.58	0.33	1.90	0.044
Mojokerto	rainy	chinese yam skin	1	0.071	1.80	0.51	1.35	0.170
		Cynodon dactylon	1	0.339	0.71	0.34	2.14	0.016
		sweet potato vine	1	0.402	1.91	0.42	2.75	0.180
		chopped native grass[a]	4	0.338	1.05	0.39	2.32	0.262
	dry	corn stover	1	0.080	0.48	0.57	1.03	0.025
		Cynodon dactylon	2	0.289	0.43	0.19	2.15	0.025
		sugar cane leaf	1	0.150	0.35	0.13	2.27	0.014
		chopped native grass[a]	2	0.290	1.11	0.40	2.24	0.210

[a]Species are undefined.

for analysis. All diet samples were dried at 60°C for 48 hours and finely ground by a ball mill.

Analytical Methods

Plasma samples were deproteinized by 10% trichloroacetic acid and the supernatant was used for measurement of Pi, Ca and Mg. One gram of each forage sample was digested in 10ml of a 4:1 mixture of 60% nitric and perchloric acids. Phosphorus was determined by a colorimetric method of Gomori (1942) and Ca, Mg, K and Na were measured by atomic absorption spectrophotometry. Hematocrit was measured by micro hematocrit method immediately after collection. Hemoglobin concentrations were determined by cyanmethemoglobin method using the Hemoglobin-Test Wako reagent kit (Wako Pure Chemical Industries LTD. Osaka, Japan).

Statistical Analysis

The mineral concentrations in forage and plasma samples were statistically analyzed as a following mathematical model.

$$Y = \mu + P_i + S_j + (PS)_{ij} + E_{ijk}$$

where

Y = each mineral concentration
μ = the overall mean
Pi = the effect associated with sampling place
Sj = the effect associated with sampling season
(PS)ij = the interaction effect between sampling place and season
Eijk= residual

All statistical analyses were conducted using General Linear Model (GLM) procedure of Statistical Analysis System (SAS) program package (Barr et al. 1985). The null hypothesis that a pair of least square means in each effect is equal was tested.

Results

Mineral Concentrations in Forage

The P content in forages from three places ranged from 0.068 to 0.402% on a dry matter basis (table 1). *Cynoden dactylon* from Jonggol showed lower P content than that from Malang and Mojokerto. The P content in sweet potato vine from Malang and Mojokerto and corn stover from Malang was higher than that in the other

TABLE 2. MINERAL CONCENTRATIONS OF FORAGE SAMPLES FROM THREE PLACES IN INDONESIA

Season	No. of Samples	Phosphorus	Calcium	Magnesium	Potassium	Sodium
		% on a dry matter basis				
		Jonggol				
Rainy	9	0.11 ± 0.04[a]	0.83 ± 0.24	0.19 ± 0.06	1.47 ± 0.34	0.14 ± 0.39
Dry	4	0.13 ± 0.04	0.61 ± 0.19	0.20 ± 0.11	1.65 ± 0.79	0.50 ± 0.57
		Malang				
Rainy	7	0.28 ± 0.09	0.93 ± 0.65	0.33 ± 0.10	2.19 ± 0.24	0.06 ± 0.07
Dry	8	0.20 ± 0.09	0.44 ± 0.14	0.27 ± 0.07	1.98 ± 0.47	0.06 ± 0.07
		Mojokerto				
Rainy	7	0.31 ± 0.15	1.24 ± 0.64	0.41 ± 0.12	2.21 ± 0.52	0.11 ± 0.07
Dry	6	0.23 ± 0.10	0.65 ± 0.36	0.31 ± 0.18	2.01 ± 0.50	0.11 ± 0.10
		Significance of differences between means				
Place		**	NS	**	**	NS
Season		NS	**	NS	NS	NS
Place x Season		NS	NS	NS	NS	NS

**p $<$ 0.01, NS not significant
[a]Mean ± SD

forages. The overall means of P content in forages from Jonggol, Malang and Mojokerto were 0.11, 0.24 and 0.27% respectively and a significant difference of P content in forages was observed between Jonggol and the other two places ($p < 0.01$, table 2). The Ca content in forages from three places ranged from 0.27 to 2.31% and sweet potato vine from Malang and Mojokerto showed higher Ca content than the other forages (table 1). The overall mean of Ca content in forage in rainy season was significantly higher than that in dry season ($p < 0.01$, table 2).

The Mg and K content in forages from three places ranged from 0.10 to 0.57% and 0.92 to 2.75% respectively (table 1). An analysis of Na content in forages showed a wide variety of values ranging from 0.007 to 1.19% and *Setaria sphacelata* from Jonggol showed extremely high Na content (table 1).

Blood Compositions

The results are presented in table 3. The plasma Pi concentrations in Jonggol, Malang and Mojokerto were 4.71, 7.00 and 6.65mg/dl respectively on the average of two seasons. A significant difference was observed between Jonggol and the other two places ($p < 0.01$). In Jonggol, the mean Pi concentration in rainy season showing 4.26mg/dl was significantly lower than that in dry season showing 5.17mg/dl ($p < 0.01$). However, no significant difference between seasons was found in Malang and Mojokerto.

The plasma Ca concentrations in rainy and dry season were 10.67 and 10.06mg/dl in Jonggol, 10.08 and 9.88mg/dl in Malang and 10.02 and 9.52mg/dl in Mojokerto. The plasma Mg concentrations in rainy and dry season were 2.29 and 2.63mg/dl in Jonggol, 2.08 and 2.33mg/dl in Malang and 2.04 and 2.42mg/dl in Mojokerto.

The hematocrit in Jonggol, Malang and Mojokerto showed 32.8%, 56.3% and 47.2% respectively in the dry season. A significant difference was found among the three places ($p < 0.01$). The hemoglobin concentration in blood in Malang and Mojokerto was 13.8g/dl and that in Jonggol was 11.9g/dl on the average of two seasons. A significant difference was observed between Jonggol and the other two places ($p < 0.01$).

Discussion

The phosphorus requirement for dry pregnant

TABLE 3. BLOOD COMPONENTS OF CATTLE FROM THREE PLACES IN INDONESIA

Season	No. of Samples	Plasma			Blood	
		Inorganic Phosphorus (mg/dl)	Calcium (mg/dl)	Magnesium (mg/dl)	Hematocrit (%)	Hemoglobin (g/dl)
			Jonggol			
Rainy	19	4.26 ± 0.88	10.67 ± 0.44	2.29 ± 0.18	NA	11.96 ± 1.32
Dry	19	5.17 ± 1.38	10.06 ± 0.51	2.63 ± 0.19	32.8 ± 3.9	11.82 ± 1.48
			Malang			
Rainy	25	7.24 ± 0.88	10.08 ± 0.53	2.08 ± 0.18	NA	13.83 ± 1.42
Dry	25	6.76 ± 0.88	9.88 ± 0.39	2.33 ± 0.22	56.3 ± 7.9	13.72 ± 1.58
			Mojokerto			
Rainy	25	6.82 ± 1.01	10.02 ± 0.49	2.04 ± 0.27	NA	13.11 ± 1.79
Dry	25	6.47 ± 1.87	9.52 ± 0.49	2.42 ± 0.32	47.2 ± 8.3	14.39 ± 1.94
			Significance of differences between means			
Place		**	**	**	**	**
Season		NS	**	**	NA	NS
Place x Season		*	NS	NS	NA	*

*p <0.05, **p <0.01, NS not significant, NA not analysed
[a]Mean ± SD

mature beef cows weighting 350kg and medium frame bulls weighing 315kg gaining 0.22kg daily is 0.18% by the NRC standard (1984). The P content of all forages from Jonggol was below the requirement (table 4) whereas the mean P content in forage from Malang and Mojokerto was above the requirement. One of the causes of difference of forage P content among places may have been the difference of forage species. However, the low P content in forage from Jonggol was likely to be partly caused by low plant availability of P from soil because the P content in *Cynodon dactylon* from Jonggol was lower than that from the other two places (table 1). The critical level of plasma Pi concentration of beef cattle recommended by McDowell et al. (1983) was 4.5mg/dl. Fifty three percent of the plasma samples in rainy season and thirty two percent of the plasma samples in dry season showed Pi concentrations below this level in Jonggol, while the plasma Pi concentrations in the other two places exceeded this level except for one sample (table 5). The low plasma Pi concentrations in cattle from Jonggol were likely due to the low P content in forage. On the other hand, it was considered that normal plasma Pi concentrations in cattle from Malang and Mojokerto reflect the sufficient P content in forage.

TABLE 4. PERCENTAGES OF FORAGE SAMPLES LESS THAN THE REQUIREMENT[a]

Seasons	Phosphorus	Calcium	Magnesium	Potassium	Sodium
		Jonggol			
Rainy	100	0	0	0	89
Dry	100	0	0	0	71
		Malang			
Rainy	14	0	0	0	71
Dry	38	0	0	0	75
		Mojokerto			
Rainy	14	0	0	0	43
Dry	33	0	0	0	50

[a]Values are cited from NRC standard (1984). phosphorus, 0.18%; calcium, 0.21%; magnesium, 0.1%; potassium, 0.65%; sodium, 0.08% (on a dry matter basis).

The Ca requirement for dry pregnant mature beef cows weighing 350kg is 0.16% and medium frame bulls weighing 315kg gaining 0.22kg daily is 0.21% according to the NRC standard (1984). The Ca content of all forages from three places exceeded the requirement (table 4) and was higher than that in forages from other regions in tropical Asia. Vijchulata et al. (1983) reported that Ca content in forages from Central Thailand ranged from 0.18 to 1.49% and Hayashi et al. (1985) reported that Ca content in forages from grassland around Medan in Smatra was 0.37 ± 0.35% (mean ± SD). McDowell et al. (1983) recommended that the critical level of plasma Ca concentration of cattle was 8 mg/dl. No plasma sample below this level was observed in the three places (table 5).

TABLE 5. PERCENTAGES OF PLASMA SAMPLES LESS THAN THE CRITICAL LEVEL[a]

Season	Inorganic Phosphorus	Calcium	Magnesium
		Jonggol	
Rainy	53	0	0
Dry	32	0	0
		Malang	
Rainy	0	0	40
Dry	0	0	8
		Mojokerto	
Rainy	0	0	44
Dry	4	0	8

[a]Values are cited from a review of McDowell et al. (1983). phosphorus: 4.5mg/dl, calcium: 8mg/dl, magnesium: 2mg/dl

The Ca concentrations in forage and plasma samples indicated that the Ca intake was likely sufficient in all the three places.

Wise et al. (1963) indicated that a dietary Ca:P ratio below 1:1 or above 7:1 reduced the growth and feed efficiency. Young et al. (1966) observed that the availability of P and plasma Pi concentration of sheep were lowered by a diet with low P and high Ca:P ratio. The Ca:P ratios calculated from mean Ca and P content in forages showed adequate values within the range from 1:1 to 7:1 with the exception of the one from Jonggol in rainy season which was estimated 7.7:1. It was considered that the generally low P content in forages was reflected to the low plasma Pi concentrations in Jonggol, with the high Ca:P ratio in forages during rainy season being responsible for further reduction in plasma Pi concentrations during this season.

The Mg requirement in forage for beef cattle is 0.1% according to the NRC standard (1984). No forage sample which contained Mg below this level was observed (table 4). McDowell et al. (1983) observed that normal Mg concentrations in plasma of cattle ranged from 2.0 to 3.5 mg/dl. All plasma samples showed Mg content above 2.0 mg/dl in Jonggol (table 5), which indicated that cattle in Jonggol were normal in Mg status. On the other hand, 40% of plasma samples from Malang and Mojokerto were below this value in the rainy season. Low Mg and high K content in forage have been assumed to be decisive factors inducing hypomagnesemic tetany. However, in Malang and Mojokerto, the forage Mg content was assumed to be sufficient and K content did not exceed the maximum tolerable level (3%). The cause of low plasma Mg concentrations in Malang and Mojokerto was not clear.

The Na requirement for beef cattle is 0.08% according to the NRC standard (1984). A few forages contained tremendously high concentrations and contributed in raising up the mean values of Na content. Two thirds of samples actually were below 0.08% (table 4) and half the samples showed extremely low concentrations less than 0.03%. Cattle might be deficient in Na when forages with low Na concentrations form the major part of their diet.

Lumsden et al. (1980) reported that hematocrit of normal cattle ranged from 24 to 36. The samples in Jonggol showed values between this range, while all samples in Malang and two thirds of samples in Mojokerto exceeded the upper level of this range. Cattle in tropical regions have shown hematocrit with a wide variety between places and seasons. Kiatoko et al. (1982) observed that hematocrit of grazing cattle in the dry season was 53.9 and 28.5 in Southeast and Central Florida in the U.S.A. respectively. Vijchulata et al. (1983) observed that hematocrit of cattle in both the dry season and wet season in Central Thailand was 36.6 and 48.3 respectively. It has been assumed that water deficiency is a major factor that increases hematocrit of cattle. However, the cattle both from Malang and Mojokerto could access to water supplies immediately before they were slaughtered. The cause of high hematocrit of cattle from Malang and Mojokerto was not clear.

Lumsden et al. (1980) observed that the hemoglobin concentrations of normal beef cattle ranged from 8.5 to 13.2g/dl. No sample below the lower limit of this range was found in any place and half the samples in Malang and Mojokerto were above the upper limit of this range. A significant positive correlation was found between hematocrit values and hemoglobin concentration ($R = 0.76$, $p < 0.01$). The difference of hemoglobin concentrations between Jonggol and the other two places was likely to reflect the difference of hematocrit between places.

In the present study, mineral satus of cattle raised in all over Java can not be discussed because only three places were investigated. However, the most noteworthy finding was that the low plasma Pi concentrations of cattle from Jonggol was likely due to the low P content and wide Ca:P ratio in forages. Low P content in forage has often been observed in tropical Asia (Hayashi et al. 1985 and Vijchulata et al. 1983) and the places where forages showed high Ca content may be widespread in Java because the Ca concentrations in forages from all three places showed high values. Thus special attention should be paid to P concentration and Ca:P ratio in forages in Java.

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