Nutritive Evaluation of Forage Plants Grown in South Sulawesi, Indonesia II. Mineral Composition

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ABSTRACT : In order to evaluate the nutritive value of the forage plants in South Sulawesi, Indonesia, 266 samples (61 grasses and 65 legumes grown in the dry season, 60 grasses and 80 legumes grown in the rainy season) were collected from the highland and the lowland in 1998 to 2000, and were subjected to the determination of mineral composition. The mean contents of Ca, Mg, P, Na and K in grasses were 0.6, 0.3, 0.5, 0.1 and 2.3%, respectively, and in legumes were 1.8, 0.5, 0.8, 0.1 and 1.7%, respectively. The least-squares analysis of variance demonstrated as follows: For the grasses, Ca content was significantly affected by the year×season, year×altitude, and the season×altitude interactions. Mg content was significantly affected by year and season and P content was significantly affected by altitude, year and by the year×altitude interaction. For the legumes, Ca content was significantly affected by altitude and the year×season, season×altitude and the year×altitude interactions and Mg content was significantly affected by season or altitude and by the year×season interaction. These results indicate that Ca content of forage plants grown at the lowland in rainy season was higher than at the highland in dry season. Mg content of forage plants grown at the lowland in dry season was higher than at the highland in rainy season and P content of forage plants grown in the highland was higher than in the lowland. ***(Asian-Aust. J. Anim. Sci. 2004. Vol 17, No. 1 : 63-67)***

Key Words : Mineral Composition, Forage Plants, South Sulawesi, Indonesia

INTRODUCTION

South Sulawesi located in eastern region of Indonesia has an extensive area of grassland and a large number of both large and small ruminants. However, there exist a seasonal imbalance between forage quality and animal requirement in that region (Bulo et al., 1994).

Most of the ruminants in South Sulawesi are kept by small farmers and the feedstuffs offered are derived mostly from waste or fallow land, crop residues and tree leaves, which have a low nutritive value on the whole. In this context, the shortage of high quality feed is one of the serious problems retarding the development of ruminant industry in South Sulawesi.

Mineral composition of forage is an important factor that controlled the quality (ARC, 1980) and would be affected by a number of factors, including climate, topography, plant species, and soil characteristics. The mineral concentration of forage plants grown in some other parts of Indonesia was reported in some studies (Little, 1986; Panjaitan, 1988; Haryanto, 1992). However, the mineral composition of forages grown in South Sulawesi, especially the effects of season and altitude have not been reported.

In this study, the mineral compositions of forages grown in the different season and altitude were examined to obtain the information for ruminant feeding in South Sulawesi.

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MATERIALS AND METHODS

A detailed explanation of the site and sample collection management was given in our previous paper (Nasrullah et al., 2003). Consequently, only a very brief description of the site and methods is presented here. South Sulawesi located in Eastern Indonesia (latitude 0° 12' N to 8° 0' S, longitude 116° 48' to 122° 36' E). The region has two different seasons: a rainy season and dry season, and also has two different areas: a highland and lowland area. Two hundred and sixty samples (61 grasses and 65 legumes grown in the dry season, 60 grasses and 80 legumes grown in the rainy season) were collected from the representative areas of highland (Enrekang regency) and lowland (Gowa-Jeneponto regency) from 1998 to 2000. A detailed explanation of the site weather conditions was given in our previous paper (Nasrullah et al., 2003)

Chemical analysis

Phosphorus (P) content was determined by the colorimetric technique. The atomic absorption/flame spectrophotometer (AA-610S Shimadzu) was used for calcium (Ca), magnesium (Mg), sodium (Na) and potassium (K) determinations. All determinations, according to A Manual of Experiment for Plant Biology method (1995), were carried out in duplicate.

Table 1. Mineral composition of grasses (% in dry matter)

Species	n	Ca[1]	Mg[2]	P[3]	Na[4]	K[5]
		Mean±SD	mean±SD	mean±SD	mean±SD	mean±SD
Bothriochloa pertusa (Beardgrass)	2	0.51±0.03	0.44±0.42	0.68±0.57	0.04±0.06	1.04±0.18
Brachiaria brizantha (Palisadegrass)	7	0.56±0.34	0.72±0.41	0.26±0.11	0.23±0.13	2.75±0.96
Brachiaria decumbens (Signalgrass)	11	0.37±0.13	0.29±0.28	0.48±0.58	0.06±0.08	2.42±0.78
Brachiaria humidicola (Koroniviagrass)	2	0.36±0.28	0.44±0.23	0.25±0.06	0.35±0.32	1.31±0.04
Brachiaria mutica (Paragrass)	1	0.64	0.04	0.26	0.22	4.12
Brachiaria ruziziensis (Congograss)	1	0.45	0.09	1.17	0.14	0.96
Cenchrus ciliaris (Buffelgrass)	2	0.32±0.01	0.60±0.01	0.39±0.07	0.09±0.00	2.43±0.53
Cotario catalya (Cotario)	1	1.21	0.09	0.30	0.01	2.16
Cynodon dactylon (Bermudagrass)	1	0.43	0.15	0.33	0.02	1.86
Digitaria milanjiana (Digitgrass)	3	0.98±0.90	0.38±0.23	0.59±0.58	0.07±0.06	1.66±0.92
Euchlaena mexiana (Euchlaena)	4	0.34±0.23	0.24±0.25	0.17±0.05	0.06±0.05	2.49±1.81
Imperata cylindrica (Cogongrass)	13	0.45±0.22	0.42±0.54	0.26±0.26	0.05±0.04	0.99±0.98
Native grasses	15	0.65±0.38	0.35±0.28	0.49±0.57	0.06±0.05	1.61±0.65
Panicum maximum (Guineagrass)	11	0.56±0.50	0.36±0.29	0.33±0.14	0.05±0.04	2.90±1.33
Paspalum notatum (Bahiagrass)	2	0.65±0.07	0.11±0.05	2.05±0.89	0.01±0.01	1.62±0.26
Pennisetum purpureum (Napiergrass)	15	0.49±0.29	0.30±0.25	0.36±0.23	0.05±0.04	3.84±1.38
Pennisetum purpupoides (Kinggrass)	6	0.47±0.35	0.41±0.29	0.83±1.48	0.08±0.04	2.64±1.36
Setaria sphacelata (Golden timothy)	12	0.45±0.16	0.28±0.24	0.66±1.19	0.12±0.09	4.42±1.62
Urachloa pullulans (Witgrass)	4	0.78±0.40	0.38±0.33	0.36±0.16	0.06±0.06	3.24±2.69
Vetiver zizanioides (Vetiver)	8	0.36±0.16	0.37±0.18	0.18±0.07	0.09±0.06	1.76±0.53
Overall mean		0.55±0.22	0.32±0.13	0.52±0.44	0.09±0.07	2.31±0.69

[1] Ca: calcium, [2] Mg: magnesium, [3] P: phosphorus, [4] Na: sodium, [5] K: potassium.

Table 2. Mineral composition of legumes (% in dry matter)

Species	n	Ca[1]	Mg[2]	P[3]	Na[4]	K[5]
		Mean±SD	mean±SD	mean±SD	mean±SD	Mean±SD
Acacia confusa (Acacia)	4	1.27±0.52	0.38±0.34	0.58±0.65	0.04±0.04	0.82±0.24
Aeschynomene americana (American jointvetch)	5	1.93±0.71	0.44±0.34	0.73±1.19	0.06±0.06	1.68±0.50
Alysucarpus vaginalis (Alyceclover)	8	2.44±1.67	0.65±0.49	0.40±0.51	0.08±0.06	1.44±0.19
Arachis hypogaea (Groundnut)	7	2.84±1.82	1.11±0.79	0.85±1.52	0.06±0.04	2.22±0.71
Calliandra calothyrsus (Calliandra)	5	1.57±1.32	0.41±0.60	0.78±1.20	0.02±0.03	1.00±0.14
Calopogonium muconoides (Calopo)	9	1.71±1.41	0.63±0.51	0.81±1.28	0.06±0.05	2.07±0.36
Cassia pillosa (Cassia)	2	1.00±0.17	0.45±0.46	0.92±1.18	0.04±0.03	0.97±0.41
Centrosema plumieri	1	1.49	0.03	1.86	0.02	1.99
Centrosema pubescens (Centro)	10	1.06±0.41	0.54±0.39	0.72±0.94	0.07±0.04	1.92±0.52
Codariocalyx gyroides	5	1.30±0.34	0.36±0.47	0.85±1.25	0.03±0.03	1.98±0.35
Clitoria ternatea (Clitoria)	4	2.59±1.77	0.60±0.84	1.06±1.55	0.11±0.09	1.45±0.24
Desmodium rensonii (Desmodium)	5	1.18±0.22	0.47±0.48	0.75±1.05	0.03±0.03	1.94±0.43
Desmanthus virgatus (Desmanthus)	2	4.05±2.69	1.20±0.78	0.21±0.01	0.08±0.05	1.74±0.17
Dioclea guyanensis	1	1.23	0.04	1.61	0.01	1.30
Flemengia congesta (Flemengia)	5	0.77±0.07	0.33±0.31	0.56±0.63	0.02±0.03	1.70±0.37
Gliricidia sepium (Gliricidia)	15	2.34±2.01	0.64±0.74	0.68±0.96	0.05±0.05	2.19±0.74
Leucaena leucocephala (Leucaena)	15	2.05±1.17	0.48±0.48	0.47±0.75	0.04±0.04	1.85±0.50
Macroptilium atropurpureum (Siratro)	9	1.85±1.27	0.58±0.53	0.36±0.45	0.05±0.04	2.04±0.74
Macroptilium lathyroides (Phasey bean)	3	1.34±0.36	0.77±0.67	0.65±0.86	0.05±0.03	1.54±0.14
Mimosa pudica (Sensitive plant)	1	1.17	0.08	0.74	0.01	1.09
Sesbania grandiflora	15	1.91±1.16	0.56±0.68	0.63±0.73	0.25±0.22	2.06±0.78
Sesbania sesban (Sesbania)	5	2.00±0.68	0.52±0.62	0.64±0.87	0.06±0.06	2.13±0.58
Stylosanthes guianensis (Stylo)	9	1.42±0.74	0.46±0.56	0.33±0.39	0.05±0.04	1.85±0.60
Overall mean		1.76±0.72	0.51±0.16	0.75±0.39	0.06±0.04	1.69±0.21

[1] Ca: calcium, [2] Mg: magnesium, [3] P: phosphorus, [4] Na: sodium, [5] K: potassium.

Statistical analysis

Data from the experiments were analyzed using Mixed Model Least-Squares and Maximum Likelihood Computer Program of Harvey (1990) and 2 to 15 replications were

Table 3. Result of least-squares analysis of variance (grasses)

Source of variation	df	Mean squares				
		Ca	Mg	P	Na	K
n=121						
Species	19	0.001568	0.000478	0.001651	0.000160	0.070339***
Year	1	0.000706	0.022108***	0.049597***	0.000344	0.186555***
Season	1	0.000156	0.026197***	0.000060	0.000084	0.019357
Altitude	1	0.004525	0.000295	0.013024*	0.000027	0.013724
Year×season	1	0.005105*	0.000143	0.000413	0.000041	0.030021
Year×altitude	1	0.004332*	0.000172	0.017505***	0.000071	0.020198
Season×altitude	1	0.024280***	0.001010	0.000612	0.000016	0.003369
Residual	95	0.001353	0.000419	0.002145	0.000157	0.001292

* p< 0.05. ** p< 0.01. *** p<0.001. For abbreviations. see the footnote of Table 1.

Table 4. Result of least-squares analysis of variance (legumes)

Source of variation	df	Mean squares				
		Ca	Mg	P	Na	K
n=145						
Species	22	0.021651***	0.000881	0.005130	0.000354***	0.007015**
Year	1	0.032486*	0.094681***	0.218726***	0.000375	0.009521*
Season	1	0.018374	0.098414***	0.009181	0.000176	0.005081
Altitude	1	0.078855**	0.004465**	0.005312	0.000100	0.001003
Year×season	1	0.090004**	0.002011*	0.008131	0.000198	0.001102
Year×altitude	1	0.165122***	0.001872*	0.008345	0.000242	0.001837
Season×altitude	1	0.412596***	0.000071	0.008757	0.000161	0.000068
Residual	116	0.007396	0.000589	0.005868	0.000122	0.002968

* p< 0.05. ** p< 0.01. *** p<0.001. For abbreviations. see the footnote of Table 1.

made in the model as already described in our previous paper (Nasrullah et al., 2003).

RESULTS

Mineral composition

The mineral compositions of grasses and legumes were shown in Table 1 and 2, respectively. The mean of Ca. Mg and P contents of legumes (1.8, 0.5 and 0.8%. respectively) were higher than those of grasses (0.6, 0.3 and 0.5%, respectively). conversely. Na and K contents of legumes (0.06 and 1.7%) were lower than those of grasses (0.1 and 2.3%).

In the grasses, Ca content ranged from 0.3% in *C. ciliaris* to 1.2% in *C. catalya*. The lowest Mg content (0.04%) was found in *B. mutica*, and the highest (0.7%) in *B. brizantha*. The P content ranged from 0.2% in *E. mexiana*, to 2.0% in *Paspalum*. The Na content varied from 0.01% in *C. catalya* to 0.3% in *B. humidicola*. The K content varied widely from 0.9% in *B. ruzuzuensis* to 4.4% in *S. sphacelata*.

In the legumes, Ca content varied widely from 0.7% in *F. congesta* to 4.0% in *D. virgatus*. The Mg content ranged from 0.03% in *C. plumeiri* to 1.2% in *D. virgatus*. The lowest P content (0.2%) was found in *D. virgatus* and the highest (1.8%) in *C. plumeiri*. The Na content ranged from 0.01% in *D. guyanensis* and *M. pudica* to 0.2% in *S. grandiflora*. The K content varied from 0.8% in *A. confusa* to 2.2% in *A. hypogaea*.

Effect of species, year, season and altitude

The results of least-square analysis of variance for grasses and legumes were shown in Table 3 and 4. respectively. For the grasses, the season had no significant effects for all of mineral contents except Mg. The altitude had significant effect on P content only, and the species had significant effect on K content only. The year had significant effects for Mg. P and K contents. It was observed that the interactions of year×altitude for Ca and P contents. of year×season and season×altitude for Ca content were significant.

For the legumes. the species had significant effects for Ca. Na and K contents. The year had significant effects for all of mineral contents except Na. The season had no significant effects except Mg content. The altitude had significant effects for Ca and Mg contents. It was observed that the interactions of year×season and year×altitude for Ca and Mg contents and of season×altitude for Ca content were significant.

DISCUSSION

It was observed, as well known (Miller. 1984; Minson. 1990), that the forage grasses have a tendency to be lower in Ca. P and Mg than those of legumes forage. Conversely, Na and K contents of grasses were generally higher than those in legumes forage (McDonald et al, 1995). The Ca content was higher than those (0.4-0.6%) for grasses and (1.2-1.6%) for legumes reported by Loneragan et al., (1968) and Metson and Saunders (1978). This result indicates that Ca content of forage satisfied the animal requirements specified by the ARC (1980). The Mg content in grasses and legumes were higher than the dietary requirements of sheep and cattle, as recommended by the ARC (1980). This result indicates that the forage plants grown in South Sulawesi are not deficient in the point of hypomagnesemic tetany. The hypomagnesemic tetany in the ruminant grazing on tropical forage have not been reported (Minson, 1990), which validates our finding that Mg content of grasses and legumes is higher than the dietary requirement of sheep and cattle. On the other hand, the mean of Na content of grasses and legumes (0.09 and 0.06%) was less than (0.22%) reported by Minson (1990) for 671 values cited in the scientific literature. As some authors (Underwood, 1971; Morris and Murphy, 1972) have pointed out that voluntary intake is depressed by a deficiency of Na, the forages in South Sulawesi might be deficient in Na for normal voluntary intake. Additionally, some grasses (e.g. Napiergrass and Bahiagrass) in this study, the mineral content was similar to those as mentioned in Standard Tables of Feed Compositions in Japan (2001). Moreover, Ca, Mg and P contents of some legumes were slightly higher than those reported by Panjaitan in Indonesia (1998).

The results of analysis of variance indicate that, P content in grasses was significantly affected by year ($p<0.001$) and by the altitude ($p<0.05$). And also the interaction of year×altitude was significant ($p<0.01$). For Ca content, year×season, year×altitude and season×altitude interactions were significant. In the legumes, Ca content was significantly affected by altitude ($p<0.01$) and the interactions of year×season ($p<0.01$), season×altitude and the year×altitude ($p<0.001$). These results indicate that the forage plants grown at the lowland in the rainy season were higher in Ca content than those at highland in the dry season. However, P content was higher at the highland than those at the lowland. This may result from the fact that temperature during rainy season and at the highland is relatively low, therefore, Ca and P contents should be higher in forage plants grown at highland and in the rainy season, as Minson (1990) has pointed out the forage plants grown at low temperature is relatively high in Ca and P. On the other hand, Mg content of grasses was significantly affected by year or season ($p<0.001$), but was not affected by any interactions. However, Mg content of legumes was significantly affected by season ($p<0.001$) and altitude ($p<0.01$), but season×altitude interaction was not significant. These results indicate that forage plants grown at highland in the rainy season were lower in Mg content than those at lowland in the dry season. Moreover, these results are similar to NCA reports (1976), in which it was found that mineral contents of forage were generally lower in the rainy season, because particularly in certain areas the high rainfall leached out the minerals from the soil.

It is concluded that the mineral compositions of forage grown in South Sulawesi were affected by plant species, season and altitude. As ruminant production is largely influenced by both the quantity and the quality of feed consumed, the results from this study suggest that it is important to find new ways to improve mineral contents feeds and feeding system in South Sulawesi. This may be implemented through the improvement of native pasture on communal grazing areas, together with proper fertilizer and grazing management.

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