Journal of Stored Products and Postharvest Research Vol. 2(5), pp. 104 -109, May 2011
Available online http://www.academicjournals.org/JSPPR
ISSI 21410- 6567 ©2011 Academic Journals

Full Length Research Paper

Dry matter and macro mineral dissapereance of selected grass in West Sumatra, Indonesia

M. Evitayani[1]*, A. Fariani[2], L. Warly[1], T. Itani[3] and T. Fujihara[4]

[1]Faculty of Animal Science, Andalas University-Padang 25163, Indonesia.
[2]Faculty of Agriculture, Sriwijaya University-Palembang 30139, Indonesia.
[3]Department of Life Sciences, Faculty of Life Environmental Sciences 727-0023, Prefectural University of Hiroshima, Japan.
[4]Faculty of Bioresources, Mie University, Tsu-Shi, 514-8507, Japan.

Accepted 11 April, 2011

The experiment was carried out to determine macromineral disappearance of tropical grass in West Sumatra during rainy and dry seasons. The forages evaluated consisted of three species of grass (*Axonopus compressus*, *Pennisetum purpureum* and *Brachiaria decumbens*) collected at native pasture. The mineral solubility was determined by *in situ* nylon bag technique through incubating the forages samples in the rumen at 0, 24 and 72 h. Results of the experiment showed that, disappearance of dry matter (DM) and minerals (solubility) significantly ($p<0.05$) affected by species and seasons. At 0 h incubation, the DM disappearance was approximately 16 and 25%. The highest DM disappearance was found in *P. purpureum* (approximately 20%) for grass. Data on macromineral showed that, P was the most soluble mineral in water followed by S, Mg and Ca, respectively in grass. Among species of grass, the highest water solubility of Ca was found in *B. decumbens*, P in *P. purpureum*, Mg in *B. decumbens* and S was found in *B. decumbens*. At 24 h incubation period, the disappearance of DM and macromineral of forages was higher than at 0 h incubation. The average increase was approximately 7.5% units for grass. The disappearance value at 72 h incubation, represents the actual solubility of minerals when forages are given to ruminants. The average DM disappearance of grass was approximately 60%, the highest value occurred in *P. purpureum*. Data on mineral solubility showed the average Ca disappearance of grass, 71.3%, the highest value, w, occurred in *B. decumbens* in West Sumatra. The average disappearance of P and Mg in grass with the highest values, were observed in *P. purpureum* and *B. decumbens*, respectively. Furthermore, the average S disappearance of grass was approximately 58%, the highest value was found in *A. compressus*. In general, the trend solubility of macromineral in legumes was: Ca > Mg > S > P.

Key words: Solubility, grass species, macro minerals.

INTRODUCTION

In ruminant animals, the essential minerals are required not only for the host animals but also for the microbes living in the rumen. They are needed by rumen microbes for the cell functions, growth and their activity. Moreover, the essential minerals also contribute to the regulation of some physicochemical characteristics of the ruminal medium such as osmotic pressure, buffering capacity, redox potential and dilution rate, all of which affect the extent of ruminal fermentation. In assessing mineral requirements of animals, both the quantity of minerals in the feeds and their bioavailability must be considered. The former can be determined by chemical analysis while the latter is much difficult to assess. *In situ* nylon bag technique has been considered to be used for determining the mineral bioavailability by incubating forage sample in the rumen of fistulated ruminants. This technique can measure the extent and rate of release of minerals in the rumen, where most of the organic matter is digested.

*Corresponding author. E-mail: evita2829@yahoo.com. Tel/Fax: 62-813741717262/62-751-71464.

The *in situ* nylon bag technique has been used with varying success in the determination of dry matter, crude protein and fiber degradabilities. Only few studies with this technique deal with ruminal solubility of minerals, such as Playne et al. (1978), Rooke et al. (1983), van Eys and Reid (1987), Emanuele and Staples (1990) and Ledox and Matz (1991). None of them reported work on forages from the tropical forages. Therefore, the present study was aimed to evaluate the minerals solubility of selected forages in West Sumatra, Indonesia during dry and rainy seasons through measurement of minerals disappearance from nylon bag, after the forage samples are incubated in the rumen at certain periods. The data could be used to help in formulating a diet for the ruminants in the tropics where mineral deficiencies are common (McDowell, 1985) and mineral supplementations are either rare or none at all.

MATERIALS AND METHODS

Study area

The study was conducted in Padang (West Sumatra). The provinces certainly have a tropical climate influenced by two seasons within the year, the rainy and dry seasons. The province West Sumatra lies between 0°30 N to 3°30 South and between 98°36 to 101°53 East with the land area of about 49.778 km^2. There are two seasons in the provinces, the dry season begins from June to September and rainy season relatively occurs from October to May. The average of rainfall in West Sumatra is about 2.289 mm per year. The daily temperature of West Sumatra varies from 24 to 32°C and 73 to 84% in West Sumatra, respectively. The land of West Sumatra consists of almost 11 kinds of soil; Organosol, Litosol, Alluvial, Grey Hidromorf, Klei Humus, Regosol, Andosol, Rendzina, Latosol, Lateritik and Podzolik.

Collection of forages samples

The forages evaluated consisted of three grass species (*Axonopus compressus*, *Pennisetum purpureum* and *Brachiaria decumbens*) that represent common forages fed to ruminants. The forages were collected from native pasture during rainy season (November, January and March) and dry season (May, July and September). The grass samples were taken from native pasture of the grazing lands. The grass samples were taken from grazing lands using a quadrant of 0.5 x 0.5 m size. The sampling plots were established in the grazing land diagonals and transverse within the sampling plots. A quadrant was thrown at every 5 m along the transverse or diagonal. Within the quadrant grass samples were cut at about 3 cm height from the ground. The forage samples were put in plastic bags and then oven dried at 60°C for 48 h and then coarsely milled to pass a 1 mm screen and then packed in the special laboratory polyethylene bag for further analyses.

Determination of dry matter and mineral disappearance of grass

Disappearance of dry matter (digestibility) and mineral (solubility) was measured by *in situ* (nylon bag) technique (Ørskov, 1985). Approximately 5 g of each forage sample were placed into nylon bags and incubated in the rumen of ruminaly cannulated Japanese Corriedale wethers at 24 and 72 h incubation period. Water soluble fractions of DM and mineral (0 h incubation) were determined by washing of the samples in the nylon bags for 30 min until rinsing water was colorless. Disappearance of forage minerals from the nylon bags during incubation was considered as solubilized minerals in the rumen. The animals were fed on Timothy hay and concentrate mixture consisting of rolled barley, rice bran and soybean meal in two equal portions twice daily at 8:00 AM and 5:00 PM to meet the nutrient requirement microbial activity (AFRC, 1993). A mineral premix block and drinking water were freely available.

Statistical analysis

Data on dry matter and minerals disappearance of *in situ* nylon bag studies were subjected to analysis by using General Linear Model procedure using StatView® (SAS, 1999). The mean comparison between species of forages and seasons were carried out by the analysis of variance and the least significant difference. The following statistical model was used in the analysis:

$$Y_{ijk} = \mu + S_i + L_j + F_k + e_{ijk,}$$

Where: Y_{ijk} = Dependent variable (general observation); μ = The overall mean; S_i = Effect of i^{th} season; L_j = Effect of j^{th} location; F_k = Effect of k^{th} species and e_{ijk} = Error term.

RESULTS AND DISCUSSION

Disappearance of dry matter and macro mineral at 0 h incubation

The effects of season and species on disappearance of DM (*in situ* digestibility) and mineral disappearance (solubility) of the forages at 0 h incubation are presented in Table 1. The analysis of variance (ANOVA) showed that, DM and Ca disappearance of grass and legumes were significantly ($p<0.05$) affected by species and season. In rainy season, *in situ* DM digestibility of grass varied from 14.5 (*A. compressus*) to 20.2% (*P. purpupureum*), while in dry season the value was relatively lower, ranged from 16.3 (*P. purpureum*) to 19.2% (*B. decumbens*). As shown in Table 1, except for Ca, proportion of disappeared P, Mg and S of grass were greater than their DM disappearance. Within species of grass during rainy season, 19.4% of Ca in *A. compressus* was disappeared at 0 h incubation and 15.5% in *P. purpureum* in dry season. Disappearance of Ca at 0 h incubation for grass harvested in West Sumatra was average 19.5%.

Result of the statistical analysis also showed that, at 0 h incubation and season significantly affected ($p<0.05$) disappearance of P, Mg and S from forages during both seasons. In rainy season, disappearance of P from grass ranged from 50.5 (*A. compressus*) to 60.6% (*P. purpupureum* and *B. decumbens*), while in dry season disappearance of P varied from 22.5 to 55.5% (*A. compressus*). In general, disappearance of P at 0 h incubation from grass in West Sumatra was 50.1%. Data on Mg disappearance of grass during rainy season

Table 1. Disappearance of dry matter and macromineral at 0 h incubation (%) of grass species during rainy and dry seasons in West Sumatra.

Forages (grass)	Season	DM	Ca	P	Mg	S
	Rainy	14.5	19.4	50.5	12.4	30.4
A. compressus	Dry	17.5	17.5	55.5	10.5	19.2
	Se	*	**	**	Ns	***
	Rainy	20.2	20.5	60.6	30.4	39.8
P. purpureum	Dry	16.3	15.5	22.5	21.5	34.4
	Se	*	**	***	***	*
	Rainy	17.2	22.4	60.6	40.4	40.6
B. decumbens	Dry	19.2	21.5	50.9	45.6	41.5
	Se	*	NS	***	**	Ns
Mean of grass	Overall	17.5±1.6	19.5±1.6	50.1±2.1	26.8±1.5	34.3±0.4
	Species	***	**	***	**	***
Sig. of effect	Season	Ns	*	*	*	**
	Spe. X Sea.	**	**	**	**	*

Se: Season effect in rainy and dry seasons; *** : P<0.001; ** : P<0.01; * : P<0.05 and Ns : non significant.

showed that, the lowest value was observed for *A. compressus* (12.4%) while the highest occurred in *B. decumbens* (60.6%). Similarly, in dry season the lowest disappearance of Mg occurred in *A. compressus* (10.5%) and the highest was noted in *B. decumbens* (45.6%). Among grass species, the highest water solubility (disappearance at 0 h incubation) of S occurred in *B. decumbens* (40.4% in rainy and 41.5% in dry season) and the lowest was noted in *A. compressus* (30.4% in rainy and 19.2% in dry season). Disappearance of S at 0 h incubation for grass harvested in West Sumatra was an average 34.3%.

Previous study of Emanuele and Staples (1990) showed that, Bermuda grass which belongs to the same genus as carpet grass (*A. compressus*) had 52.9% solubility in water. However, other grass such as *P. purpureum* had very low Ca solubility in water (below 5%). The lower solubility of Ca in dry season could be due to the least effect of leaching on this element as reported by Ibrahim et al. (1990). Calcium is also not readily solubilized by water in most tropical and even temperate forages. This element is bound as calcium oxalates and either trapped or attached in the cell wall of grass and legumes (McManus et al., 1979). The water solubility of P in the present study varied from 10.4 to 70.4%, this finding was relatively lower compared to the results of Ibrahim et al. (1990) who reported that 60 to 83% of total P in ground plant material is a water-soluble fraction. The variation of water soluble fraction of P was also reported by several researchers; 65.5% on subtropical forages (Emanuele and Staples, 1990 and Ibrahim et al., 1990), 85.0% (Whitehead et al., 1985) and 66.8% (Ledoux and Martz, 1991) on temperate forages. The lower water solubility of P in this study might be caused by the forage used in this study had more P attached, trapped or crystallized in the cell walls. The trend in the rate of mineral water solubilities of grass harvested at rainy and dry seasons was: P > Mg > S > Ca. The same order was observed by Emanuele and Staples (1990). This partly agreed with the observation of Ibrahim et al. (1990) and Ledoux and Martz (1991), except in Mg and P, although the former is less soluble than the latter. Thus, the proportion of minerals solubilized by water are associated to the soluble fraction of the forages and they are immediately available for the host animal and their ruminal microbes.

Disappearance of dry matter and macro mineral at 24 h incubation

The effects of species and seasons on DM and macromineral disappearance of forages at 24 h incubation are presented in Table 2. The analysis of variance (ANOVA) showed that, DM and Ca disappearance of grass species were significantly ($p<0.05$) affected by season and species. As expected, at 24 h incubation period, the disappearance of DM and macromineral was higher than at 0 h incubation. The average increase in West Sumatra was 7.5%. In rainy season, *in situ* DM digestibility of grass varied from 21.2 (*A. compressus*) to 32.3% (*P. purpureum*), while in dry season the value was relatively lower, ranged from 22.4 (*B. decumbens*) to 26.3% (*A. compressus*). Similarly, the

Table 2. Disappearance of dry matter and macromineral at 24 h incubation (%) of grass species during rainy and dry seasons in West Sumatra.

Forages (grass)	Season	DM	Ca	P	Mg	S
	Rainy	21.1	30.2	60.1	20.2	40.2
A. compressus	Dry	26.3	22.5	59.1	18.2	22.1
	Se	*	**	*	*	***
	Rainy	32.3	33.2	77.2	37.4	45.6
P. purpureum	Dry	22.4	21.4	64.2	29.5	40.2
	Se	***	**	***	***	*
	Rainy	24.3	45.5	65.5	50.2	55.2
B. decumbens	Dry	22.4	50.5	60.4	50.1	56.7
	Se	*	*	***	NS	Ns
Mean of grass	Overall	25.0±1.0	35.3±0.7	48.8±2.5	34.3±1.7	40.1±0.5
	Species	***	**	***	**	***
Sig. of effect	Season	Ns	*	*	*	*
	Spe. X Sea.	**	**	**	**	*

Se: Season effect in rainy and dry seasons; *** : P<0.001; ** : P<0.01; * : P<0.05 and Ns : non significant.

Ca disappearance of grass harvested in West Sumatra at 24 h incubation varied from 30.2% (*A. compressus*) to 45.5% (*B. decumbens*) during rainy season while in dry season the values were varied from 21.4 (*P. purpureum*) to 50.5% (*A. compressus*). The average Ca disappearance of grass harvested in West Sumatra was 35.3%.

Result of the statistical analysis also showed that, at 24 h incubation and season significantly affected (p<0.05) disappearance of P, Mg and S from forages during both seasons. In rainy season, disappearance of P from grass ranged from 60.1 (*A. compressus*) to 77.2% (*P. purpupureum*), while in dry season disappearance of P varied from 59.1 (*A. compressus*) to 64.2% (*P. purpureum*). In general, disappearance of P at 24 h incubation from grass in West Sumatra was 48.8%. Data on Mg disappearance of grass during rainy season showed that, the lowest value was observed for *A. compressus* (20.2%) while the highest occurred in *B. decumbens* (50.2%). Similarly, in dry season the lowest disappearance of Mg occurred in *A. compressus* (18.2%) and the highest was noted in *B. decumbens* (50.2%). Among grass species, the highest water solubility (disappearance at 24 h incubation) of S occurred in *B. decumbens* (55.2% in rainy and 56.7% in dry season) and the lowest was noted in *A. compressus* and *P. purpureum* (40.2% in rainy and 22.1% in dry season). Disappearance of S at 24 h incubation for grass harvested in West Sumatra was an average of 40.1%. As shown in Table 2, the trend of ruminal solubility of macromineral at 24 h incubation period in grass during rainy and dry seasons was : P > S > Mg > Ca. This finding agreed with the result reported by Ledoux and Martz (1991) in temperate forages including silage and with result of van Eys and Reid (1978), that P was more soluble than Mg in fescue and red clover herbage.

Dry matter and macromineral disappearance of forages at 72 h incubation

Dry matter and macromineral disappearance of forages at 72 h incubation are shown in Table 3. It is clear that DM and macromineral disappearance of the forages at 72 h incubation was higher compared to 24 h incubation. The average DM disappearance of grass during rainy season in West Sumatra was 60.1%, with the highest value occured in *P. purpureum* (63.2%) while the lowest occurred in *B. decumbens* (57.4%). In dry season, DM disappearance varied from 57.4 (*B. decumbens*) to 63.5% (*P. purpureum*). Data on mineral solubility showed that, the average Ca disappearance of grass within species of grass during rainy season, 81.5% of Ca in *B. decumbens* was disappeared at 72 h incubation and 62.6% in *A. compressus.* The disappearance of Ca at 72 h incubation for grass harvested in West Sumatra was average 71.3%.

Result of the statistical analysis also showed that, at 72 h incubation and season significantly affected (p<0.05) disappearance of P, Mg and S from forages during both seasons. In rainy season, disappearance of P from grass ranged from 68.4 (*B. decumbens*) to 90.4% (*P. purpupureum*), while in dry season disappearance of P varied from 62.1 (*B. decumbens*) to 83.5%

Table 3. Disappearance of dry matter and macromineral at 72 h incubation (%) of grass species during rainy and dry seasons in West Sumatra.

Forages (grass)	Season	DM	Ca	P	Mg	S
	Rainy	58.3	62.6	79.9	43.2	65.4
A. compressus	Dry	57.6	66.4	77.6	40.1	54.1
	Se	NS	**	*	*	***
	Rainy	63.2	69.5	90.4	35.9	59.4
P. purpureum	Dry	63.5	67.5	83.5	30.8	55.1
	Se	NS	**	***	***	*
	Rainy	60.5	81.5	68.4	59.4	57.6
B. decumbens	Dry	57.4	80.4	62.1	57.7	63.4
	Se	*	NS	***	*	***
Mean of grass	Overall	60.1±1.3	71.3±0.8	77.0±2.4	44.5±1.2	59.2±0.3
	Species	***	**	***	**	***
Sig. of effect	Season	Ns	*	*	*	**
	Spe. X Sea.	**	**	**	**	*

Se: Season effect in rainy and dry seasons; ***: P<0.001; **: P<0.01; * : P<0.05 and Ns : non significant.

(*P. purpupureum*). In general, disappearance of P at 72 h incubation from grass in West Sumatra was 77.0%. Data on Mg disappearance of grass during rainy season showed that, the lowest value was observed for *P. purpupureum* (35.9%) while the highest occurred in *B. decumbens* (59.4%). Similarly, in dry season the lowest disappearance of Mg occurred in *P. purpupureum* (30.8%) and the highest was noted in *B. decumbens* (57.7%). The disappearance of Mg at 72 h incubation for grass harvested in West Sumatra was an averge of 44.5%. Among grass species, the highest water solubility (disappearance at 72 h incubation) of S occurred in *A. compressus* (65.4% in rainy season) and 63.4% in dry season (*B. decumbens*) while, the lowest was noted in *B. decumbens* (57.6%) during rainy season and 54.1% (*A. compressus*) in dry season.

Furthermore, the average S disappearance of grass was 59.2% in West Sumatra. The values observed in the present study were similar to those of earlier reports, that average DM disappearance of various forages incubated at 48 and 72 h in the rumen was 73.4% (temperate forages) and 69.9% (subtropical forages), respectively (Ledoux and Martz, 1991; Emanuele and Staples, 1990) but it was higher than reported by Playne et al. (1978) at 72 h even at 168 h incubation periods. The differences might be due to the differences in washing procedures (hand washing vs mechanical washing, amount of water used in rinsing) and maturity of forages used, in which percentage release of mineral decreases as plant maturity increases. The trend of the mineral solubilities was: Ca > P > S > Mg for grass.

ACKNOWLEDGMENTS

The author is indebted to the Directorate of Higher Education (DHGE) of Indonesia, for the full financial support by “International Research Collaboration and Publication” foundation

Conclusion

In conclusion, among the forage species and seasons, differences exist on the solubility of macrominerals (Ca, P, Mg and S). Minerals solubility increased as increasing period of incubation from 0 to 72 h. At 0 h incubation (water solubility), P and Mn were the most soluble minerals. Conversely, Ca has been solubilized lower than the other observed minerals. Among species of forages, *Pennisetum purpuphoides* contained highly water soluble minerals compared to the other species. Data on macrominerals showed that at 72 h incubation (actual solubility), P was the most soluble minerals in grass followed by Ca, S and Mg. Consistent with mineral concentration, among the forages evaluated *P. purpuphoides* had higher mineral solubility compared to the other species.

REFERENCES

Agricultural and Food Research Council (AFRC) (1993). Energy and Protein Requirements of Ruminants. CABI, Wallinford, UK.

Emanuele SM, Staples CR (1990). Ruminal release of mineral from six

forage species. J. Anim. Sci., 68: 2052-2060.
Ibrahim MNM, Van Der Kamp A, Zemmelink G, Tamminga T (1990). Solubility of mineral elements present in ruminant feeds. J. Agric. Sci. (Camb), 114: 265-274.
Ledoux DR, Martz FA (1991). Ruminal solubilization of selected macro minerals from forages and diets. J. Dairy Sci., 74: 1654-1661.
McDowell LR (1985). Nutrition of Grazing Ruminants in Warm Climates. Academic Press, Orlando, p. 443.
McManus WR, Robinson VNE, Grout LL (1979). The physical distribution of mineral material on forage plant cell wall. Aust. J. Agric. Res., 28: 651-662.
Ørskov ER (1985). Evaluation of crop residues and agro-industrial by-products using the nylon bag method. In : Guidelines for Research on Crop Residues. ILCA-FAO Publications, pp. 126-133.
Playne MJ, Echevarria MG, Megarrity RG (1978). Release of nitrogen sulfur, phosphorus, calcium, magnesium, potassium and sodium from four tropical hays during their digestion in nylon bags in the rumen. J. Sci. Food Agric., 29: 520-526.
Rook JA, Akinsoyinu AO, Armstrong DG (1983). The release of mineral elements from grass silages incubated *in sacco* in the rumens of jersey cattle. Grass Forage Sci., 38: 311-316.
SAS/Statview (1999). Using statview. Statistical Analytical System (SAS) Inc. Third edition. SAS Inc, Cary, NC, USA, p. 288.
Van EJE, Reid RL (1987). Ruminal solubility of nitrogen and minerals from fescue and fescue-red clover herbage. J. Anim. Sci., 65: 1101-1112.
Whitehead DC, Goulden KM, Hartley RD (1985). The distribution of nutrient elements in cell wall and other fractions of the herbage of some grasses and legumes. J. Sci. Food Agric., 36: 311-318.