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ORIGINAL ARTICLE

Nutritive value of selected grasses in North Sumatra, Indonesia

EVITAYANI,[1] Lili WARLY,[2] Armina FARIANI,[3] Toshiyoshi ICHINOHE,[4] Shaukat A. ABDULRAZAK,[5] Maki HAYASHIDA[4] and Tsutomu FUJIHARA[4]

[1]*The United Graduate School of Agricultural Sciences, Tottori University, Tottori-shi and* [4]*Laboratory of Animal Science, Faculty of Life and Environmental Science, Shimane University, Matsue-shi, Japan,* [2]*Faculty of Animal Science, Andalas University, Padang and* [3]*Faculty of Agriculture, Sriwijaya University, Palembang, Indonesia, and* [5]*Division of Research and Extension, Egerton University, Njoro, Kenya*

ABSTRACT

The nutritive values of seven native grass species collected in North Sumatra, Indonesia, during dry and rainy seasons were evaluated. The chemical composition, *in vitro* dry matter digestibility (IVDMD), *in vitro* organic matter digestibility (IVOMD), *in vitro* crude protein digestibility (IVCPD), macro mineral concentrations of calcium, phosphorus and magnesium, *in vitro* gas production profile and metabolizable energy (ME) content of the grasses varied greatly among species and seasons. The crude protein content ranged from 6.6 (*Andropogon gayanus*) to 16.2% dry matter (*Cynodon plectostachyus*) in the rainy season, with a significant ($P < 0.05$) reduction in the dry season. Data on the fiber fraction showed that the grasses contained more neutral detergent fiber (NDF) and acid detergent fiber (ADF) in the dry season and it significantly ($P < 0.05$) decreased in the rainy season, except for *Panicum maximum* and *Pennisetum purpureum* for NDF content and *C. plectostachyus, P. maximum* and *Brachiaria decumbens* for ADF content. Data on the mineral concentration showed that *C. plectostachyus* in the dry and rainy seasons had a higher calcium content than those of other species. The overall means of the seven grasses for IVDMD, IVOMD and IVCPD were significantly higher ($P < 0.05$) in the rainy season than in the dry season. The *in vitro* gas production and ME concentration were numerically higher in the rainy season than in the dry season. In conclusion, the nutritive value of the observed grasses in North Sumatra was relatively higher during the rainy season compared with the dry season. Among the species of grass, *P. purpureum* and *C. plectostachyus* had a higher nutritive value in both the dry and rainy seasons.

KEYWORDS: dry season, grass species, nutritive value, rainy season.

INTRODUCTION

In smallholder farming systems, native forages and agriculture by-products are the main sources for ruminant feeds in Indonesia. The potential of any feed to support animal production depends on the quantity consumed by the animal and the extent to which the feed meets energy, protein, mineral and vitamin requirements (Minson 1990). The nutritive value of some tropical grasses has been evaluated in both laboratory and feeding practices. The results have shown that the nutritive value of forages is a result of the combined effects of genetic and environmental factors. Genetic factors include the species, strain within the species, type of growth and response to environmental factors. Some environmental factors are: climate, weather, soil fertility, fertilizer application and management (Sulivan 1973).

Correspondence: Tsutomu Fujihara, Laboratory of Animal Science, Faculty of Life and Environmental Science, Shimane University, Matsue-shi, 690-8504, Japan. (Email: fujihara@life.shimane-u.ac.jp)
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A previous study has showed that the nutritive value of legumes assessed by nutrient digestibility and metabolizable energy (ME) content varied greatly among species and it was higher in the rainy season than in the dry season (Evitayani *et al*. 2004a). Until now, there has been no information available concerning the nutritive value of grasses in North Sumatra in relation to the difference in seasons; therefore, the aim of the present study was to evaluate the nutritive value of grasses by determining the chemical composition, mineral concentration, *in vitro* digestibility, *in vitro* gas production and estimation of ME content during the dry and rainy seasons. Part of the current study has been briefly described in a study by Evitayani *et al*. (2004b).

MATERIALS AND METHODS

Collection of forage samples

The forage samples were collected from a natural pasture in Medan, North Sumatra, during the dry and rainy seasons. The province is located in a tropical and monsoon region and lies between 98–100°E and 1–4°N. There are two seasons in the year – a rainy season and a dry season. The months of the rainy season are: September, October, November, December, January and February with a mean monthly rainfall of 345, 350, 299, 398, 143 and 256 mm, respectively. The months of the dry season are: March, April, May, June, July and August with a mean monthly rainfall of 144, 219, 250, 201, 108 and 232 mm, respectively. The daily temperature ranges from 18 to 34°C, the annual rainfall varies from 1100 to 3400 mm, the mean monthly rainfall is approximately 192 mm in the dry season and 298 mm in the rainy season, and the relative humidity ranges between 79 and 96%. The seven grass species evaluated in the present study are common grasses fed to ruminants as a basal food in North Sumatra. They were: gamba grass (*Andropogon gayanus*), carpet grass (*Axonopus compressus*), signal grass (*Brachiaria decumbens*), star grass (*Cynodon plectostachyus*), guinea grass (*Panicum maximum*), king grass (*Pennisetum purpuphoides*) and napier grass (*Pennisetum purpureum*). The grass samples were collected by cutting the young vegetative portion (leaves and stem) of the plant during early blooming. The grass samples were taken from a grazing pasture using a quadrant of 0.5 m × 0.5 m in area. Quadrants were built every 5 m along the transverse or diagonal. Within a quadrant, grass samples were cut at a height of approximately 3 cm from the ground. The yield of grass species per year in grazing lands is approximately 10 ton/ha. The representative samples were dried at 60°C for 48 h, ground to pass a 1 mm screen and sent to Japan for further analyses.

Determination of chemical composition

The chemical composition of the grass, that is, the dry matter (DM), organic matter (OM), crude protein (CP) and ether extract (EE), were analyzed using the standard procedure described by the AOAC (1990). The fiber fractions, namely, neutral detergent fiber (NDF), acid detergent fiber (ADF) and acid detergent lignin (ADL), of the samples were analyzed according to the method described by Goering and Van Soest (1970). The calcium, phosphorus and magnesium concentrations of the samples were analyzed using an inductively coupled plasma emission spectrometer (SPS7700; Seiko Instruments, Chiba, Japan) after the samples were digested with nitric acid.

In vitro digestibility

The *in vitro* DM digestibility (IVDMD), *in vitro* OM digestibility (IVOMD) and *in vitro* CP digestibility (IVCPD) of the samples were determined according to the methods described by Tilley and Terry (1963) and Goering and Van Soest (1970). The rumen fluid samples for the *in vitro* digestion study and the measurement of *in vitro* gas production test were taken from three adult sheep (bodyweight, 70 kg) fitted with rumen cannulae (outer diameter, 70 mm). The animals were fed a diet sufficient to meet their maintenance requirements (AFRC 1993). The animals were fed 1.2 kg of timothy hay and 0.4 kg of a concentrate mixture consisting of wheat bran and rolled barley in the ratio of 2:1 divided into two equal meals at 08.00 and 16.00 hours. Mineral blocks and drinking water were freely available. The rumen fluids were taken at 4 h after the morning feeding.

One part of the rumen fluid was mixed with two parts of a medium consisting of *in vitro* rumen buffer solution, macro and micro mineral solutions, resazurine and reduction solutions. One gram of each forage sample was incubated in the rumen fluid–buffer medium mixture for 96 h. After the *in vitro* digestion, all of the incubated materials were filtered and dried at 60°C for 96 h to determine the IVDMD. The residues were then analyzed for CP and OM content to determine the IVOMD and IVCPD.

In vitro gas production and metabolizable energy content

The *in vitro* gas production was measured using syringes according to the method described by Menke *et al*. (1979). The gas produced was read at a series of incubation times at 3, 6, 12, 24, 48, 72 and 96 h. The exponential equation proposed by Ørskov and McDonald (1979) was used to determine the characteristics of gas production using the Neway–Excel computer program (Macaulay Institute, Aberdeen, UK). The following model was applied to the data:

$$Y = a + b(1 - e^{-ct})$$

where Y is the volume of gas produced (mL/200 mg DM) with time (t), a is the intercept of the gas production curve, a + b is the asymptote of the exponential curve, which represents the potential extent of the *in vitro* gas production and c is the rate of gas production (per h). The ME concentration of the forages was estimated according to the following equation (Menke & Steinngas 1988):

$$\text{ME (MJ/kg DM)} = 2.2 + 0.136 \times GP + 0.0057 \times CP + 0.00029 \times EE^2$$

where *GP* is the gas production at 24 h of incubation, *CP* is the crude protein content of the forage (g/kg) and *EE* is the ether extract content of the forage (g/kg).

Statistical analysis

Data on the chemical composition, mineral content, *in vitro* digestibility, *in vitro* gas production and ME content of the grasses were analyzed by the general linear model procedure using StatView (SAS 1999). The mean comparison between the species of grass and the seasons were carried out using ANOVA and the least significant difference. The following statistical model was used in the analysis:

$$Y_{ijk} = \mu + S_i + F_j + e_{ijk}$$

where Y_{ijk} is the dependent variable (general observation), μ is the overall mean, S_i is the effect of the *i*th season (*i* = dry and rainy season), F_j is the effect of the *j*th species (*j* = 1, 2, 3, 4, 5, 6, 7) and e_{ijk} is the error term.

RESULTS AND DISCUSSION

Chemical composition

The OM, CP and EE contents of the grasses are shown in Table 1. The OM content of *A. compressus, B. decumbens, P. purpuphoides* and *P. purpureum* was significantly higher ($P < 0.05$) in the dry season than in the rainy season. The mean value of OM was 90.8% DM in the dry season and 89.8% DM in the rainy season. The CP content of the grasses varied among species and seasons. With the exception of *A. gayanus* and *A. compressus*, the CP content was significantly higher ($P < 0.05$) in the rainy season compared with the dry season. The mean CP content in the dry season was 10.0% DM, ranging from 8.7 (*A. gayanus*) to 12.0% DM (*P. maximum*). Whereas in the rainy season, the mean CP content was 13.0% DM, ranging from 6.6 (*A. gayanus*) to 16.2% DM (*C. plectostachyus*). With the exception of *P. purpuphoides*, the EE content was higher ($P < 0.05$) in the rainy season than in the dry season, which averaged 3.0 and 1.8% DM, respectively.

Data on the fiber fraction showed that the NDF, ADF and ADL content of the grasses varied greatly among species and seasons (Table 2). The NDF content of *A. gayanus, A. compressus, B. decumbens* and

Table 1 Organic matter (OM), crude protein (CP) and ether extract (EE) content of grasses in the dry and rainy seasons (% dry matter)

Species	OM		Se	CP		Se	EE		Se
	Dry	Rainy		Dry	Rainy		Dry	Rainy	
Andropogon gayanus	87.9[a]	89.3[ab]	NS	8.7[a]	6.6[a]	*	1.2[a]	2.7[a]	*
Axonopus compressus	91.9[ab]	88.0[a]	*	10.0[cd]	10.6[b]	NS	1.7[b]	3.9[c]	**
Brachiaria decumbens	92.8[b]	89.1[a]	*	8.7[a]	12.8[c]	**	2.0[bc]	2.9[ab]	*
Cynodon plectostachyus	89.9[a]	89.1[a]	NS	11.9[c]	16.2[d]	*	1.0[a]	3.2[b]	**
Panicum maximum	91.2[ab]	90.2[b]	NS	12.0[c]	15.1[d]	*	1.2[a]	2.7[a]	*
Pennisetum purpuphoides	90.9[a]	88.8[a]	*	9.2[b]	15.2[d]	**	2.5[c]	2.7[a]	NS
Pennisetum purpureum	91.2[ab]	89.8[ab]	*	9.2[b]	14.4[cd]	**	3.1[d]	2.7[a]	*
Mean	90.8	89.8		10.0	13.0		1.8	3.0	

*$P < 0.05$. **$P < 0.01$. [abcd]Means in the same column with different superscript letters differ significantly ($P < 0.05$). NS = not significant; Se, effect of the season in the same species of grass.

Table 2 Neutral detergent fiber (NDF), acid detergent fiber (ADF) and acid detergent lignin (ADL) content of grasses in the dry and rainy seasons (% dry matter)

Species	NDF		Se	ADF		Se	ADL		Se
	Dry	Rainy		Dry	Rainy		Dry	Rainy	
Andropogon gayanus	67.0^{bc}	59.3^{b}	**	39.3^{bc}	41.5^{c}	**	6.5^{c}	5.9^{b}	*
Axonopus compressus	65.9^{b}	58.0^{ab}	**	35.4^{b}	38.2^{bc}	*	7.6^{d}	6.9^{c}	**
Brachiaria decumbens	63.9^{ab}	57.8^{a}	**	32.5^{a}	32.1^{a}	NS	7.1^{bc}	5.4^{ab}	**
Cynodon plectostachyus	60.3^{ab}	67.2^{c}	*	34.2^{ab}	36.8^{bc}	NS	6.9^{cd}	6.7^{bc}	NS
Panicum maximum	60.1^{a}	62.7^{bc}	NS	42.9^{d}	47.3^{d}	NS	4.7^{ab}	3.6^{a}	*
Pennisetum purpuphoides	72.6^{c}	63.4^{bc}	**	39.6^{c}	35.6^{b}	*	4.0^{a}	6.5^{bc}	*
Pennisetum purpureum	66.8^{bc}	66.2^{bc}	NS	38.0^{bc}	40.6^{c}	*	5.5^{b}	3.7^{a}	*
Mean	65.2	62.1		37.5	38.9		6.0	5.5	

*$P < 0.05$. **$P < 0.01$. [abcd]Means in the same column with different superscript letters differ significantly ($P < 0.05$). NS = not significant; Se, effect of the season in the same species of grass.

Table 3 Concentration of calcium, phosphorus and magnesium in grasses during dry and rainy seasons (g/kg DM)

Species	Calcium		Se	Phosphorus		Se	Magnesium		Se
	Dry	Rainy		Dry	Rainy		Dry	Rainy	
Andropogon gayanus	7.6^{bc}	8.3^{c}	*	2.9^{b}	3.7^{ab}	*	2.2^{a}	3.2^{ab}	**
Axonopus compressus	8.0^{cd}	7.4^{b}	NS	2.1^{ab}	2.9^{ab}	NS	3.9^{c}	4.2^{d}	**
Brachiaria decumbens	5.8^{ab}	6.4^{ab}	**	1.9^{a}	2.1^{a}	NS	2.9^{b}	3.6^{bc}	**
Cynodon plectostachyus	8.7^{d}	9.2^{d}	**	3.9^{c}	4.3^{c}	*	2.2^{a}	3.7^{c}	*
Panicum maximum	7.9^{c}	6.9^{ab}	*	3.4^{bc}	3.9^{b}	NS	3.9^{c}	3.0^{b}	*
Pennisetum purpuphoides	5.4^{a}	6.1^{a}	*	3.7^{c}	4.4^{c}	*	2.9^{b}	2.4^{a}	NS
Pennisetum purpureum	6.2^{b}	6.3^{ab}	NS	3.2^{bc}	5.8^{d}	**	3.1^{bc}	3.6^{bc}	NS
Mean	7.1	7.2		3.0	3.9		3.0	3.4	

*$P < 0.05$. **$P < 0.01$. [abcd]Means in the same column with different superscript letters differ significantly ($P < 0.05$). NS = not significant; Se, effect of the season in the same species of grass.

P. purpuphoides was significantly higher ($P < 0.01$) in the dry season than in the rainy season. The mean value of NDF in the dry and rainy season was 65.2 and 62.1%, respectively. With the exception of *C. plectostachyus* and *P. purpuphoides*, the ADL content of the grasses was significantly lower ($P < 0.05$) in the rainy season than in the dry season. The mean ADL content was 6.0% DM in the dry season, ranging from 4.0 (*P. purpuphoides*) to 7.6% DM (*A. compressus*), whereas in the rainy season, the mean value of ADL was 5.5% DM, ranging from 3.6 (*P. maximum*) to 6.9% DM (*A. compressus*).

Such seasonal changes in the chemical compositions of grasses in tropical climates are a result of the maturity and age of the grass species with the progression of seasons from the dry to rainy season. The lower CP content in the dry season was in agreement with the results reported by Aregheore (2002) and Evitayani *et al*. (2004a). The wide variation in the CP and fiber contents of the forages were consistent with previous reports (Fariani 1996; Tudsri & Kaewkunya 2002; Islam *et al*. 2003; Nasrullah *et al*. 2003). Minson (1990) showed that the CP concentration of 560 tropical forages ranged from 2 to 27% DM depending on the growth stage and soil fertility. The differences in the fiber components between seasons suggested that the high intensity of solar radiation and lower rainfall caused faster maturation during the dry season and this resulted in higher cell wall constituents and lower cell contents than in the rainy season. In 2001, the rainfall in North Sumatra was approximately 192.2 mm/month in the dry season, whereas it was 298.4 mm/month in the rainy season (Indonesian Statistical Bureau 2001).

Mineral concentrations

The concentrations of calcium, phosphorus and magnesium are shown in Table 3. Both the seasons and species had a significant effect ($P < 0.05$) on the calcium, phosphorus and magnesium concentrations of grass, except for *A. compressus* and *P. purpureum* (for calcium); *A. compressus*, *B. decumbens* and *P. maximum* (for phosphorus); and *P. purpuphoides* and *P. purpureum* (for magnesium). In the dry season, *C. plectostachyus* contained the highest amount of calcium and phosphorus, and *P. purpuphoides* and *B. decumbens* contained the lowest amount of calcium and phosphorus, respectively. In the rainy season, the highest concentration of calcium and phosphorus was noted for *C. plectostachyus* and *P. purpureum*, respectively. *P. purpuphoides* had the numerically lower calcium concentration and *B. decumbens* contained the lowest phosphorus concentration in both the dry and rainy seasons. In general, the concentration of calcium, phosphorus and magnesium in the rainy season was higher compared with the dry season. A study by Kumagai *et al*. (1990) in Java island, Indonesia, showed that the calcium concentration of forages in the rainy season was significantly ($P < 0.01$) higher than that in the dry season. The phosphorus content in the grasses was also slightly higher in the rainy season than in the dry season. They found a similar trend in the phosphorus concentration of the grass species in that it tended to be higher in the rainy season than in the dry season. The magnesium content in the grass species were almost the same, but tended to be higher in the rainy season than in the dry season (Kumagai *et al*. 1990; Serra *et al*. 1997). According to McDowell (1985), the critical level of calcium, phosphorus and magnesium concentration in grass is 3.0, 2.5 and 2.0 g/kg, respectively. The results of the present study showed that, except for *B. decumbens* (dry and rainy seasons) and *A. compressus* (dry season), which contained phosphorus below the critical level, there was no other species of grass deficient in calcium, magnesium or phosphorus in both the dry and rainy seasons.

In vitro digestibility

The *in vitro* digestibility of DM, OM and CP are shown in Table 4. The values of IVDMD, IVOMD and IVCPD varied greatly between the species and seasons. In the dry season, the IVOMD varied from 51.8 (*P. purpuphoides*) to 61.1% (*C. plectostachyus*), whereas in the rainy season it ranged from 51.9 (*A. gayanus*) to 64.4% (*C. plectostachyus*). The data showed that the IVDMD and IVOMD of *A. compressus*, *C. plectostachyus* and *P. purpureum* were significantly higher ($P < 0.05$) in the rainy season compared with the dry season. The higher IVDMD in the rainy season compared with the dry season was in agreement with the result found by Nasrullah *et al*. (2003). The values of IVDMD in the present study were similar to the results reported by Fariani (1996), Ammar *et al*. (1999) and Manyayu *et al*. (2003). According to Bula *et al*. (1977), the IVDMD of forage during the grazing stage varies considerably, and it relates to the changes in the chemical composition, particularly in the fiber, lignin and silica contents.

The IVCPD of grasses varied from 52.5 (*A. gayanus*) to 57.8% (*C. plectostachyus*) in the dry season, whereas in the rainy season the IVCPD varied from 50.5 (*A. gayanus*) to 60.3% (*P. maximum* and *C. plectostachyus*). The IVCPD of *A. compressus, B. decumbens* and *P. maximum* in the rainy season were significantly higher ($P < 0.05$) than in the dry season. This finding was in agreement with the result obtained by Göhl (1975), and the wide variation of IVCPD was mainly related to the different degradable CP content in the

Table 4 *In vitro* digestibility of dry matter (IVDMD), organic matter (IVOMD) and crude rotein (IVCPD) of grasses in dry and rainy seasons (%)

Species	IVDMD		Se	IVOMD		Se	IVCPD		Se
	Dry	Rainy		Dry	Rainy		Dry	Rainy	
Andropogon gayanus	48.2^{a}	49.2^{a}	NS	52.1^{ab}	51.9^{a}	NS	52.5^{a}	50.5^{a}	NS
Axonopus compressus	52.4^{b}	56.2^{b}	*	53.8^{ab}	56.7^{b}	*	53.8^{ab}	56.9^{bc}	*
Brachiaria decumbens	51.4^{b}	56.2^{b}	NS	54.9^{b}	57.2^{b}	NS	55.0^{b}	58.1^{bc}	**
Cynodon plectostachyus	57.4^{c}	62.2^{c}	**	61.6^{c}	64.4^{c}	*	57.8^{c}	60.3^{c}	NS
Panicum maximum	56.5^{c}	56.1^{b}	NS	58.7^{c}	55.6^{b}	NS	57.3^{c}	60.3^{bc}	*
Pennisetum purpuphoides	51.9^{b}	54.2^{b}	NS	51.8^{a}	54.5^{b}	NS	53.9^{ab}	55.2^{b}	NS
Pennisetum purpureum	53.2^{b}	56.3^{b}	*	59.6^{c}	62.7^{c}	**	56.7^{bc}	58.6^{bc}	NS
Mean	53.0	55.9		56.1	57.6		55.3	57.1	

$*P < 0.05$. $**P < 0.01$. [abcd]Means in the same column with different superscript letters differ significantly ($P < 0.05$). NS = not significant; Se, effect of the season in the same species of grass.

grass and fiber component. A low IVCPD was associated with lower CP and higher fiber fractions during the dry season. It has been suggested that some differences in the IVCPD of the forages are also arising as a result of the differences in the species or genotype, stage of growth, environmental conditions and management practice. Generally, *C. plectostachyus* and *P. maximum* had the highest IVDMD, IVOMD and IVCPD compared with the other grasses in both the dry and rainy seasons. These findings were consistent with their chemical compositions as shown in Table 1 and Table 2, of which *C. plectostachyus* and *P. maximum* contained much higher CP, but generally lower cell wall constituents.

Gas production and metabolizable energy content

The characteristics of *in vitro* gas production and the estimated ME content of grasses during the dry and rainy seasons are shown in Table 5. With the exception of *A. gayanus, B. decumbens* and *C. plectostachyus*, the potential gas production in the rainy season was significantly higher ($P < 0.05$) compared with the dry season. In the dry season, the mean potential gas production was 38.9 mL/200 mg DM, ranging from 30.9 (*A. compressus*) to 49.1 mL/200 mg DM (*C. plectostachyus*), whereas in the rainy season, the mean potential gas production was 41.3 mL/200 mg DM, varying from 34.2 (*A. compressus*) to 49.4 mL/200 mg DM (*C. plectostachyus*). The effect of the season showed that the potential gas production of *A. compressus, P. maximum, P. purpuphoides and P. purpureum* was statistically higher ($P < 0.05$) in the rainy season than in the dry season. In general, *C. plectostachyus* followed by *P. purpureum* in both the dry and rainy seasons had the highest potential gas production. In the present study, a positive correlation with statistical significance ($P < 0.05$) was detected between the potential gas production (Table 5) and the IVOMD (Table 4) of the tested grasses in both the dry and rainy seasons. As presented earlier, the IVOMD was highest for *C. plectostachyus* and *P. purpureum* in both the dry and rainy seasons. This means that these grasses contained more degradable fractions than the other grasses, which may have been fermented in the rumen and thus resulted in much higher volatile fatty acids and gas production (Fariani 1996). The results were also in agreement with the observations by Menke *et al.* (1979), Krishnamoorthy *et al.* (1995) and Nogueria *et al.* (1999) in that the amount of gas released when a feed is incubated *in vitro* with rumen fluid was closely related to the digestibility of the feed. As shown in Table 5, the ME content of the grasses varied from 6.0 (*A. compressus*) to 8.7 MJ/kg DM (*C. plectostachyus*) in the dry season and increased slightly from 6.4 (*A. gayanus*) to 9.3 MJ/kg DM (*C. plectostachyus*) in the rainy season. In both of the seasons, the highest ME content was prominent for *P. purpureum* and *C. plectostachyus*. The ME content of grasses in the present study was relatively higher than the ME content of several legumes in North Sumatra, varying from 6.4 to 7.8 MJ/kg in the dry season and from 6.9 to 7.8 MJ/kg in the wet season (Evitayani *et al.* 2004a).

In conclusion, the nutritive value of grasses in North Sumatra, assessed by chemical composition, *in vitro* digestibility, macro mineral concentration, gas production and ME content, was relatively higher during the rainy season than in the dry season. Among the species of grass, *P. purpureum* and *C. plectostachyus* had a higher nutritive value in both the dry and rainy seasons. The results of the present study should be valuable to farmers because it provides information

Table 5 Characteristics of *in vitro* gas production and metabolizable energy (ME) content of grasses in dry and rainy seasons

Species	GP†		Se	GP rate‡		Se	ME§		Se
	Dry	Rainy		Dry	Rainy		Dry	Rainy	
Andropogon gayanus	34.9[ab]	35.3[a]	NS	0.08[ab]	0.06[ab]	NS	6.7[b]	6.4[a]	NS
Axonopus compressus	30.9[a]	34.2[a]	*	0.05[ab]	0.04[a]	NS	6.0[ab]	6.4[a]	NS
Brachiaria decumbens	35.3[ab]	36.1[a]	NS	0.04[a]	0.04[a]	NS	5.9[a]	6.8[a]	**
Cynodon plectostachyus	49.1[c]	49.4[c]	NS	0.08[ab]	0.13[c]	*	8.7[d]	9.3[c]	*
Panicum maximum	40.0[b]	42.5[b]	*	0.10[ab]	0.06[ab]	*	7.5[c]	7.9[ab]	NS
Pennisetum purpuphoides	39.5[b]	43.7[bc]	**	0.11[b]	0.08[b]	**	7.3[bc]	8.0[b]	NS
Pennisetum purpureum	42.9[bc]	48.3[c]	*	0.07[ab]	0.06[ab]	NS	7.7[bc]	8.9[bc]	**
Mean	38.9	41.3		0.08	0.07		7.1	7.6	

†Potential gas production (mL/200 mg DM). ‡Gas production rate constant (per h). §ME = MJ/kg DM.
$*P < 0.05$. $**P < 0.01$. [abcd]Means in the same column with different superscript letters differ significantly ($P < 0.05$). GP, gas production; NS, not significant; Se, effect of the season in the same species of grass.

concerning the chemical composition and digestibility of grass species so that farmers can make full use of available forage sources.

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