YIELD AND NUTRITIVE VALUES OF SIX NAPIER *(PENNISETUM PURPUREUM)* CULTIVARS AT DIFFERENT CUTTING AGE

HARYANI H.*, NORLINDAWATI A.P., NORFADZRIN F., ASWANIMIYUNI A. AND AZMAN A.

Institut Veterinar Malaysia, KM 13 Jalan Batu Pahat, Beg Berkunci 520, 86009 Kluang, Johor, Malaysia
* Corresponding author: haryani@dvs.gov.my

ABSTRACT. Napier grass (*Pennisetum purpureum*) has been the most promising and high yielding fodder giving dry matter yields. This experiment was conducted to determine the effect of cutting intervals on the yield and nutrient composition of six cultivars of Napier grass (*Pennisetum purpureum*) which is 3rd Generation Napier, India Napier, Kobe Napier, Red Napier, Taiwan Napier and Zanzibar Napier. The grasses were cut close to the ground level to get a uniform stand on day 70 after planting and the cutting intervals were at 35 and 42 days and carried out for 3 times. After each harvest, the rates of maintenance fertiliser used were 150 kg of nitrogen, 60 kg of phosphorus and 100 kg of potassium per hectare per year. Harvested plant material was weighed, pre-dried in a forced-air drying oven at 60 °C overnight before grinding. Ground samples were used to determine dry matter (DM), crude protein (CP), crude fibre (CF) and metabolised energy. The data were analysed using Statistical Analysis System (SAS™) followed by Tukey's post-hoc test. AP value of less than 0.05 ($p<0.05$) are considered statistically significant. Results showed that increasing the cutting interval (i.e. advancing age of maturity) increased dry matter and crude fibre significantly. However, in terms of nutrient content, crude protein and metabolised energy percentage was markedly decreased as the cutting interval increased. From the results presented, it is clear that cutting a stand of Napier grass at 35 days will achieve greater yield and nutrient content.

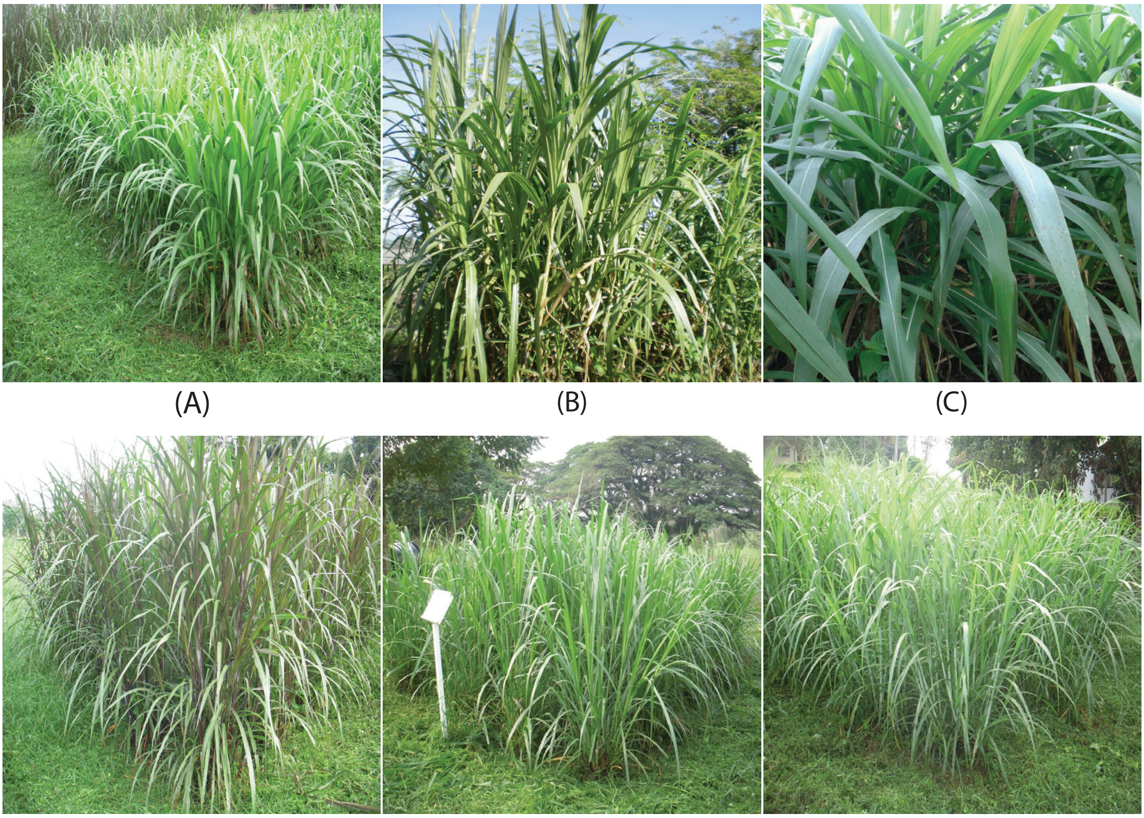
Keywords: Napier, cutting age, dry matter yield, nutritive values

INTRODUCTION

Forages continue to represent the single most important feed resource for livestock in developed and developing countries. Selecting forage species for cultivation must take into consideration the yield, digestibility and nutrient composition (Ansah *et al.*, 2010). Napier or elephant grass (*Pennisetum purpureum*) was first introduced to Malaysia in the 1920s and several cultivars had been introduced since 1950s. Napier grass is the most popular fodder used in dairy and feedlot production (Halim *et al.,* 2013). Napier grass is robust, rhizomatous, tufted and has a vigorous root system, developing from nodes of its creeping stolons. The culm is coarse, and may be up to 4 m to 7 m in height. The plant can form dense thick clumps, up to 1 m across. The leaves are flat, linear, and hairy at the base, 100 cm to 120 cm long, 1 cm to 5 cm wide and bluish-green in color. The inflorescense is a stiff terminal bristly spike, 15 cm to 20 cm in length and yellow-brown to purplish in color. Spikelets are arranged around a hairy axis. There is little or no seed formation. When seeds are present, they are very small. Napier can be propagated through seeds, however as seed production is inconsistent, collection is difficult. Alternatively, it can be propagated vegetatively by stem cuttings or stolons. After planting, Napier grass grows vigorously and can reach 4 m in 3 months (Skerman and Riveros, 1990). Napier has been the promising and high yield grass, giving dry matter yield that surpasses most other tropical grasses, like Guinea grass (*Panicum maximum*) and Rhodes grass (*Chloris gayana*) and higher nutritive value compared to *Brachiaria* sp. and *Panicum* sp. (Gomez *et al.,* 2011). There are around 25 cultivars of *Pennisetum* grass under cultivation (Kretschemer and Pitman, 2001). Many cultivars of Napier grass have been developed worldwide to suit the local conditions and there is a wide range of habits, yield potential and nutritive value. Napier grass is fast growing and has a high annual productivity that depends on climatic and soil conditions (Rusdy, 2016). Yields ranged from 20 to 80 tonnes/DM/ha/year under high fertiliser input (Skerman and Riveros, 1990). On farm, dry matter yields of Napier grass from different regions average about 16 tonnes/ha/year (Wouters, 1987). With no or inadequate fertilisers, yields are on the range of 2 to 10 tonnes/DM/ha/year (Bogdan, 1977). The composition and digestibility of Napier grasses is highly influenced by harvesting age (Lounglawan *et al.,* 2014). Napier grass can produce more dry matter per unit area than any other crop. It can be intercropped with legumes and fodder trees, or as a pure stand. The tender young leaves and stem is highly palatable to livestock (Burton, 1990). The nutritive value of grasses decrease with advancing maturity. The reduction of digestibility as the harvesting age increases is related to lignin content in the mature plant (Zailan *et al.,* 2016). Herbage yield of Napier grass affected by the harvesting day after planting (Manson, 1990). The range of protein content of Napier grass varies from 4.4 to 20.4% with the mean around 12% (Rusdy, 2016). This value is not too different from the report of Xie *et al.* (2009) that crude protein of Napier grass ranged from 4% to 5%. Age at harvest is the most important factor affecting crude protein content of elephant grass (Wadi *et al.,* 2004). As a plant ages, dry matter yield increases but crude protein declines. Such a trend in crude protein content had been reported, and it is mainly attributed to dilution of crude protein content of forage crops by rapid accumulation of cell wall carbohydrates at the advanced stage of growth (Humphreys, 1991). Therefore, this study was designed to evaluate the effect of cutting age on dry matter yield and nutritive value of six Napier cultivars (Figure 1).

MATERIALS AND METHOD

The following six cultivars of Napier were examined: 3rd Generation Napier, India Napier, Kobe Napier, Red Napier, Taiwan Napier and Zanzibar Napier. The stem cuttings of six Napier cultivars were collected from a vegetative plot at the Veterinary Institute Malaysia. Forage plots of each treatment measured 7 m by 4 m and were separated by a 1.0 m path in between. The planting materials of Napier were planted



(A) (B) (C) (D) (E) (F)

Figure 1. (A) 3rd Generation Napier; (B) India Napier; (C) Kobe Napier; (D) Red Napier; (E) Taiwan Napier; and (F) Zanzibar Napier.

in rows with spacing 0.6 m × 0.6 m. The parent plant was cut at a minimum of three nodes per cutting and were planted 15 cm to 20 cm deep at angles of about 30° to 45°. Ground magnesium limestone was added at the rate of 2 metric tonnes per hectare. Basal fertilisers used were 60 kg of nitrogen, 30 kg of phosphorus and 30 kg of potassium per hectare during grass establishment. The grass were cut close to the ground level to get a uniform stand on day 70 after planting and then the cutting treatments at the interval of 35 days and 42 days were carried out for 3 times. After each harvest, the rates of maintenance fertiliser used were 150 kg of nitrogen, 60 kg of phosphorus and 100 kg of potassium per hectare per year.

Dry matter yield

The grass was harvested by cutting a whole plot undergoing each treatment. The fresh samples harvested from each treatment were weighed. The grass yield obtained from random sample of Napier, representative of each plot treatment were pre-dried in a forced-air drying oven at 60 °C overnight before grind. The dried samples were then ground to pass 1-mm sieves and the ground samples were then put in a forced-air drying oven at 103±2 °C over 4 hours (Close *et al.,* 1986) to obtain the dry matter. The yield of dry matter per hectare was calculated.

Chemical Composition

The ground samples were used to determine the chemical composition of the grass. The CP content (N × 6.25) was determined after digestion in sulphuric acid by the Kjeldahl method using Kjeltec™ methods (FOSS™). CF was measured after being treated with boiling dilute sulphuric acid and boiling sodium hydroxide solution using Fibertec™ methods (FOSS™). Finally, the metabolised energy for ruminant was calculated using Manke equation (1986).

Statistical Analysis

The data were analysed using the general linear model (GLM) programme of SAS (Package Version 9.3). The difference between treatment means was measured by Tukey's post-hoc test. The level of significance used to determine the differences between treatments is $p<0.05$.

RESULTS AND DISCUSSION

Dry Matter Yield

Dry matter yield increased in alignment with the increased of grass maturity as shown in Table 1. The dry matter for all cultivars at 35 days showed no significant difference. The dry matter for each cultivar range from 2.9 to 3.8 tonnes/ha/harvest at 35 days cutting age. This result revealed that at the early age of growth, the Napier produced limited dry matter yield (Zailan *et al.,* 2016). However, dry matter of India Napier and Red Napier boosted up from 2.9 to 4.74 tonnes/ha/harvest at 42 days cutting age. The dry matter yield both India Napier and Red Napier showed a significant difference between 35 days and 42 days cutting age. Whereas dry matter for 3rd Generation Napier, Kobe Napier, Taiwan Napier and

Table 1. Dry Matter (tonnes/ha/cut) for six Napier cultivars at different cutting ages.

Parameter	Cultivars	Cutting age (days)	
		35	42
Dry matter yield (tonnes/ha/cut)	3rd Generation Napier	3.73^a	4.53^a
	India Napier	2.96^a	4.74^b
	Kobe Napier	3.62^a	4.12^a
	Red Napier	2.90^a	4.06^b
	Taiwan Napier	3.43^a	4.41^a
	Zanzibar Napier	3.31^a	3.41^a

Note: Means with same superscript letter in same row are not significantly different ($p>0.05$)

Zanzibar Napier showed no significant difference throughout the study.

Chemical Composition

Dry matter

The dry matter for India Napier was significantly increased with increasing plant maturity. However, there were no significant difference of DM at 35 and 42 days for other Napier cultivars. Three Napier cultivars, Zanzibar, 3rd Generation and Red Napier, show the highest DM compared to other Napier types at the same harvesting age, i.e. approximately 12% of DM content.

Crude protein content

The highest crude protein content at 35 days old was obtained by Zanzibar Napier types with 19.43% followed by Kobe Napier with 18.73%, while all the types showed CP content of approximately 17%. There were

Table 2. Chemical composition of fresh Napier cut at 35 days and 42 days of age.

Parameter	Napier	Cutting age (day)	
		35	42
DM (%)	3rd Generation	12.87^{a}	14.40^{a}
	India	9.47^{b}	12.47^{a}
	Kobe	11.97^{ab}	13.00^{a}
	Merah (Red)	12.17^{ab}	14.33^{a}
	Taiwan	10.67^{ab}	12.47^{a}
	Zanzibar	12.93^{a}	12.07^{a}
CP (%)	3rd Generation	17.50^{a}	15.03^{a}
	India	17.77^{a}	14.93^{a}
	Kobe	18.73^{a}	15.27^{a}
	Merah (Red)	17.07^{a}	13.47^{a}
	Taiwan	17.23^{a}	13.97^{a}
	Zanzibar	19.43^{a}	13.97^{a}
CF (%)	3rd Generation	35.50^{a}	34.23^{a}
	India	29.60^{b}	33.00^{a}
	Kobe	31.93^{b}	34.60^{a}
	Merah (Red)	31.47^{b}	33.20^{a}
	Taiwan	32.23^{b}	33.10^{a}
	Zanzibar	31.33^{b}	35.00^{a}
Energy/ME (MJ/kg)	3rd Generation	8.52^{b}	8.82^{a}
	India	8.76^{b}	8.71^{a}
	Kobe	8.89^{ab}	9.06^{a}
	Merah (Red)	9.59^{a}	9.00^{a}
	Taiwan	8.83^{ab}	8.75^{a}
	Zanzibar	9.09^{ab}	8.57^{a}

Note: Means with same superscript letter in same row are not significantly different ($p>0.05$)

no significant difference of CP content for all cultivars of Napier from two harvesting periods. At 42 days of harvesting period, 3rd Generation Napier, India Napier and Kobe Napier cultivars still have quite high CP content with approximately 15% compared to three other cultivars with only 13%. Although there are slightly decreasing values of CP content for all cultivars of Napier. The CP content is still above the critical level, which is more than 7%, in sustaining rumen function (Rusdy, 2016). According to Wadi *et al.* (2004), age at harvest is the most important factor affecting crude protein content in Napier grass. As the grass ages, although dry matter yield increases, crude protein content declines.

Crude fibre content

The crude fibre content of grass tends to increase in advancing maturity. The 3rd Generation Napier had highest CF content and India Napier had the lowest CF content, which is 35.50% and 29.60% respectively compared to other types of Napier at 35 days of age. At same age, other types of Napier contain approximately 31% of CF content. There were significant differences of CF content for all types of Napier from two harvesting periods except 3rd Generation Napier.

Metabolised energy

The metabolised energy for 3rd Generation and India Napier were significantly different at age 35 and 42 days. There were no significant differences between the two harvesting periods for the other four types of Napier. However, generally the metabolised energy for all types of Napier declines at 42 days of age compared to 35 days of age.

CONCLUSION

Proximate analyses revealed that although cutting on day 42 showed higher yields than cutting at day 35, the nutrient content in terms of CP and ME at 35 days cutting period was much higher. This is because the degradation is directly proportional to the age of the grass. The India Napier is more superior compared to other cultivars in terms of dry matter yield. The dry matter yield increase reach up to 60.14% at 42 days old compared to 35 days old. However, the Zanzibar Napier is more superior in nutrient value with highest nutritive values in terms of crude protein at 35 days old, while the 3rd Generation Napier showed the highest nutritive values in terms of crude protein at 42 days old. CP and ME show a decrease in line with the increase in the age of cutting while DM and CF increases as the age of cutting increase. The CP decrease from range 14.1% to 28.10% in line with increase of cutting age.

The recommended age to harvest Napier is at 6-8 weeks of growth to optimise the dry matter yield and nutritive value (Lounglawan *et al.,* 2014). Red Napier showed the highest dry matter yield compared to other cultivars (6.1 tonnes/ha/cut) at 8 weeks old (Zailan *et al.,* 2016). Dry matter yield of Taiwan Napier reached up to 7.73 tonnes/ha/harvest at 60 days old. (Haryani *et al.,* 2017). Studies could also be carried out on Pakchong Napier, a new Napier cultivar which farmers claim has the best Napier in terms of dry matter yield and nutritive values. The parameters to be emphasised are different cutting ages (at 4, 6 and 8 weeks old), dry matter intake, plant height, number of tiller/plant, leaf to stem ratio and also nutritive value of the Pakchong cultivar.

REFERENCES

1. A.O.A.C. (2000). *Official Methods of Analysis*. 17th edition. Association of Official Analytical Chemists. Washington D. C.
2. Ansah T., Osafo E.L.K. and Hanne H.H. (2010). Herbage yield and chemical composition of four varieties of Napier (*Pennisetum purpureum*) grass harvested at three different days after planting. *Agric. Biol. J. N. Am.,* 2010, **1(5):** 923-929.
3. Bogdan A.V. (1977). *Tropical Pasture and Fodder Plants*, Longman, 475 pp.
4. Burton G.W. (1993). African Grasses. In: *New Crops*. Janick J. and Simon J.E., eds. Wiley, New York. pp 294-298.
5. Close W., Menke K.H., Steingass H. and Toscher A. (1986). *Selected Topics in Animal Nutrition: A manual prepared for the 3rd Hohenheim Course Animal Nutrition in the tropics and semi-tropics*. 2nd Edition. Germany: DSE.
6. FOSS Application Note 3437. *Determination of Crude Fibre (CF) in feed using Fibertec™ 2010 or M6 according to AOAC 978.10, AACC 32-10 and AOCS Ba 6-84*.
7. FOSS Application Note AN 3001 (2003). *Determination of Crude Protein (Kjeldahl Nitrogen) in Animal Feed, Forage (Plant Tissue), Grain & Oilseeds Using Block Digestion with Copper Catalyst and Steam Distillation into Boric Acid*. Sweden: FOSS Analytical.
8. Francis J.K. (2004). *Pennisetum purpureum* Schumacher. In: *Wildland shrub of the United States and its Territories: thamnic descriptions: volume 1*. Francis J.K. ed. Gen. Tech. Rep. IITF-GTR-26. USDA Forest Service, International Institute of Tropical Forestry, 830 p.
9. Gomez R.O., Gallegos E.C., Rodriguez J.J., Hernandes R.E., Zavaleta E.O. and de la Mora B.V. (2011). Nutritive quality of grasses during the rainy season in a hot-humid climate and ultisol soil. *Tropical and Subtropical Ecosystem,* **13(20):** 481-489.
10. Halim R.A., Shampazurini S. and Idris A.B. (2013). Yield and nutritive quality of nine Napier grass varieties in Malaysia. *Malaysian Journal of Animal Science*, **16(2):** 37-44.
11. Haryani H., Norfadzrin F., Aswanimiyuni A. and Azman A. (2017). The effects of adding POME (palm oil mill effluent) in the soil on yield and nutritive values of Napier grass (*Pennisetum purpureum* cv. Taiwan). In: *Proc. 4th ARCAP and 38th Malaysian Society of Animal Production Conference*. Senai, Johor. pp. 81-82.
12. Humphreys L.R. (1991). *Tropical Pasture Utilisation*. Cambridge University Press, Great Britain.
13. Kretschemer E.A. and Pitman W.D. (2001). Germplasm resources of tropical for age grasses. In: *Tropical Forage Plant: Development and Use*. Sotomoyor-Rios A. and Pitman W.D. (eds). CRC Press, Gainesville, Florida, pp. 27-40.
14. Lounglawan P., Lounglawan W. and Suksombat W. (2014). Effect of cutting interval and cutting height on yield and chemical composition of King Napier grass (*Pennisetum purpureum × Pennisetum americanum*). *APCBEE Procedia*. **8:**27-31.
15. Minson D.J. (1990). *Forage in ruminant nutrition*. Acadmic Press, San Diego, CA. p 482.
16. Rusdy M. (2016). Elephant grass as forage for ruminant animals. *Livestock Research for Rural Development* **28(4).**
17. Skerman P.J. and Riveros F. (1990). *Tropical Grasses*. FAO Rome, Italy. p 832.
18. Wadi A., Ishii Y. and Idota S. (2004). Effect of cutting interval and cutting height and dry matter yield and overwintering ability at the established year in *Pennisetum* species. *Plant Production Science* **7:** 88-96.
19. Wouters A.P. (1987). Dry matter yield and quality of Napier grass as affected by harvesting frequency and genotype. *Agronomy Journal*. **83:** 541-546
20. Xie X.M., Zhou F., Zhang X.Q. and Zhang J.M. (2009). Genetic variability and relationship between MT-1 elephant grass and closely related cultivars assessed by SRAP markers. *Journal of Genetics*. **88:** 281-290.
21. Zailan M.Z., Yaakub H. and Jusoh S. (2016). Yield and nutritive value of four Napier (*Pennisetum purpureum*) cultivars at different harvesting ages. *Agriculture and Biology Journal of North America*. **7(5):** 213-219.

ACKNOWLEDGEMENT. The authors would like to thank the Director-General of Veterinary Services, Dato' Dr Quaza Nizamuddin Bin Hassan Nizam for his permission to publish this paper, the Director of Veterinary Institute Malaysia, Kluang, all Agronomy Unit and Feed Analysis Laboratory staff of Veterinary Institute Malaysia.