Yield and Nutritive Quality of Nine Napier Grass Varieties in Malaysia

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Abstract

Napier grass was first introduced in Malaysia in the 1920's from East Africa and is currently the most popular fodder grass in dairy and feedlot production systems. Nine varieties of Napier grass were grown in a randomized complete block design with five replications to characterize and compare their growth, agronomic performance and nutritive quality. Based on the data obtained, six of the varieties could be grouped as the tall or medium height (>130 cm) varieties and three were short or dwarf types (<95 cm). The shorter varieties had a higher (P<0.05) overall nutritive quality (CP about 12%, ADF < 37%) compared to the taller varieties (CP 10%, ADF>37%) mainly because the former had a higher leaf-to-stem ratio (1.4 in dwarf and less than 0.8 in tall varieties, P<0.05) On the other hand the tall varieties gave higher (P<0.05) cumulative dry matter yield than the shorter varieties over a 12-month period with the tallest varieties giving more than 60 t/ha while the short varieties yielded less than 60 t/ha. Farmers who place a premium on yield would be advised to use the tall varieties while those with livestock that has special needs for higher quality feed such as for dairy production would benefit from using the dwarf Napier grass varieties.

Keywords: Napier grass, varieties, nutritive quality, yield

Introduction

Napier grass (*Pennisetum purpureum)* occurs naturally throughout tropical Africa and particularly in East Africa. It is a tall, stout and deep-rooted perennial bunch grass well known for its high yielding capability and usage as forage for livestock (Woodard and Prine, 1991). Napier grass was first introduced to Malaysia in the 1920's and is currently the most popular fodder grass in dairy and feedlot production systems. Over the last two decades several Napier grass varieties have been introduced, such as the Taiwan Napier, Dwarf Napier, King Grass and Red Napier. There are morphological differences between the varieties but there have been no studies in Malaysia to investigate the variation in Napier grass and no systematic work has been conducted to examine their adaptability to the local environment, or whether there are differences in nutritive quality and agronomic characteristics between the varieties. Without such information, it is difficult to make recommendations to farmers on the choice of the Napier varieties.

Napier grass has been the most promising and high yielding fodder in Africa (Anindo and Potter, 1986). One of the few local reports comparing different varieties of Napier grass showed that King Grass, a hybrid of *P. pennisetum* and *P.*

typhoides that was introduced to Malaysia in early 1990's, showed faster growth rate than the common Napier (Halim and Suhaizi, 1994). However, the nutritive quality of Common Napier was better than King Grass as shown by its higher crude protein content and lower NDF and ADF content than King Grass. Being a fast-growing grass, King Grass has a high demand for nutrients and nitrogen fertilization is a requirement for maximum fodder yield. Comparative studies between Napier grass varieties have been more frequently conducted in its place of origin. Studies in Africa resulted in the development of a key for identifying the various Napier grass varieties using morphological and agronomic characters (Zewdu, 2005). In Ethiopia, ten Napier varieties were studied focusing on their variation in growth, yield, chemical composition and *in vitro* dry matter digestibility. Based on the results, four Napier grass varieties were categorized as being of high quality. In the morphological studies, variety Taiwan A-144 presented the highest dry matter production (Bach *et al*., 1995). Another study in Ethiopia evaluated 56 varieties of Napier grass to assess their agronomic potential (Lowe *et al*., 2003). Therefore the objectives in this study were to evaluate the agronomic performance and nutritive quality of the nine varieties of Napier grass and subsequently identify superior varieties based on those criteria.

Materials and Methods

Stem cuttings of nine varieties of Napier grass were collected from the Malaysian Agricultural Research and Development Institute (MARDI) and brought for planting at Universiti Putra Malaysia (UPM) Serdang (location 101^{o} 42'E, 2^{o} 12'N). The total rainfall received during the study period was 2700 cm (Fig. 1) with peaks in November 2009 and May 2010 and the average annual minimum and maximum air temperatures were 22^{o}C and 33^{o}C, respectively. The soil is a clay loam with pH 5.2, nitrogen 0.04%, phosphorus 29 mg kg^{-1} and potassium 0.19 cmol^{+} kg^{-1}.

The nine varieties which are known by their common names were King Grass, Common Napier, Red Napier, Taiwan Napier, Uganda Napier, Indian Napier, Dwarf Napier, Dwarf 'Mott' Napier and Australian Dwarf Napier. The Napier grass varieties were planted in plots of size 3 x 5 m using a randomized complete-block design (RCBD) with five blocks of the nine varieties in each block. There was an alleyway of 2-m width between blocks and 1-m width between plots. Grasses were planted in rows with five rows per plot spaced at 1 m between rows and 0.5 m between points in each row, giving a density of 20,000 plants/ha. Stem cuttings with at least three nodes were planted to a depth of 15-20 cm at an angle of 45^{o}.

Basal fertilizers applied during planting were 50 kg N, 50 kg P and 50 kg K per hectare using urea (46% N), triple superphosphate, TSP (20% P) and muriate of potash, MOP (50% K), respectively. The plants were allowed to establish for a period of 3 months before the first cut was taken.

There were a total of six harvests taken over a period of 12 months (24 July 2009 - 24 June 2010) with harvesting interval of 7 to 8 weeks depending on the growth rate of the grass. After every harvest, the plots were top dressed with 50 kg/ha N and after every three harvest P and K were applied at 50 kg P/ha and 50 kg K/ha. Measurements taken before each harvest included plant height and density of tillers. Plant height was based on five culms taken randomly in each plot, measured using a steel tape from the ground level to the highest leaf. The number of tillers was also measured from the five culms.

After each harvest the total dry matter yield was estimated based on samples from 1x0.5 m quadrats after drying the cut samples in forced-air oven at 65°C over 4 days. Leaves were separated from stems and the leaf-to-stem ratio (LSR) was estimated based on the dry weight of each component for each sample. The dried samples were then ground to pass a 1-mm sieve and the ground samples were used for laboratory crude protein (CP), neutral-detergent fibre (NDF), acid detergent fibre (ADF) and acid-detergent lignin (ADL) analyses. Crude protein was determined using an auto analyzer after digestion in sulphuric acid by the Kjeldahl Method (AOAC, 1990). Neutral Detergent Fiber, ADF and ADL concentrations in ground plant samples were determined using the method of Van Soest *et al*. (1991) with a modification for NDF where the FOSS Fibertec™ FiberCap fibre extraction system (Kitcherside *et al*., 2000) was used instead of the traditional Gooch crucibles.

Differences among varieties were tested using analysis of variance and where differences were significant, means separation using Duncan's Multiple Range Test was carried out using SAS 9.2 (SAS Institute, 2011). A correlation analysis was also conducted to examine relationships between the yield, morphology and nutritive quality variables.

Results and Discussion

The analysis of variance (Table 1) indicated significant differences among varieties in plant height, tiller density and leaf-to-stem ratio but there were no significant differences in cumulative dry-matter yield over the 12-month period. Table 2 shows the clear separation of the varieties into two distinct groups, where six of the varieties, namely: King Grass, Common Napier, Red Napier, Taiwan Napier, Uganda Napier and Indian Napier were not significantly different from each other and the plant height were all greater than 139 cm. The other three varieties: Dwarf, Dwarf 'Mott' and Australian Dwarf were significantly shorter in stature ($P<0.01$ using group contrasts) with average height of less than 95 cm. The short varieties of Napier also showed greater degree of tillering than the taller varieties. Dwarf 'Mott' had the highest density of tillers with a mean of 19.6 tillers per plant while the tall varieties had less than 14.2 tillers per plant (Table 2). This suggests that in dwarf varieties, partitioning of photosynthates was more towards tillering at the expense of stem elongation while the opposite was true for the tall varieties. As expected, the short internodes of the dwarf varieties made the group recorded higher leaf-stem-ratio (mean of 1.33) compared to the taller varieties with leaf-stem ratio mean of 0.87 (Table 2). This has significant implications on the nutritive quality of the grass as leaves contain higher levels of nutrients and less fibre than stems. Zewdu (2005) also found the highest leaf-stem ratio (LSR) was from the shortest varieties of Napier. His study showed that the shorter Napier varieties (height of 78 cm) recorded LSR as high as 8.7.

Table 1: Mean squares from analysis of variance for agronomic performance for 9 varieties of Napier grass over the 6 harvests

Source of variation	df	Plant height	No. of tillers	Leaf-stem ratio	Dry matter yield cumulative	Dry matter yield harvest 2
Block	4	47.04	4.06	0.02	61716146**	7848333
Varieties	8	4951.03**	40.02**	0.40**	8222414	30258055*
Error	32	119.62	2.38	0.05	5242929	13372708
CV %		8.91	10.14	21.95	23.78	20.54

**significant at p≤0.01, *significant at p≤0.05

Table 2: Morphological characteristics and dry matter yield of nine Napier grass varieties

Variety	Plant height (cm)	Number of tillers/plant	Leaf to stem ratio	Dry matter yield at harvest 2 (kg/ha)	Cumulative dry matter yield (t/ha)
King grass	145[a]	12.6[bc]	0.80[de]	15,840[a]	61.6[ab]
Common Napier	139[a]	14.8[b]	0.87[cde]	14,420[a]	65.1[a]
Red Napier	139[a]	13.5[bc]	0.92[bcde]	12,640[ab]	59.8[ab]
Taiwan Napier	146[a]	11.9[c]	0.68[e]	11,120[ab]	60.4[ab]
Uganda	147[a]	13.7[bc]	1.01[bcd]	11,640[ab]	65.9[a]
Indian Napier	144[a]	14.2[b]	0.92[bcde]	11,440[ab]	56.7[ab]
Dwarf Napier	95[b]	18.1[a]	1.63[a]	11,580[ab]	51.0[ab]
Dwarf 'Mott'	79[c]	19.6[a]	1.22[b]	8,720[b]	55.9[ab]
Australian Dwarf	71[c]	18.7[a]	1.15[c]	8,000[b]	43.7[b]

[abcde] Means with common superscripts are not significantly different (P>0.05) using DMRT

Although the cumulative dry matter yield over the six harvests were not significantly different between varieties (Table 1), there were significant differences at harvest 2 (Table 2) where the shorter varieties had lower dry matter yields than the taller varieties. These results are similar to those reported by Zewdu (2005) and Ishii *et al.* (2005), where the taller varieties showed higher dry matter yields. Dry matter decreased markedly for all varieties at harvest 5 and 6 and this was associated with the lower rainfall in June and July of 2010 compared to that in May (Figure 1). Over the period of study, Uganda Napier recorded a numerically higher cumulative dry matter yield of 65,891 kg ha^{-1} yr^{-1} compared with Australian Dwarf with only 43,703 kg ha^{-1} yr^{-1} although the differences were not statistically significant (P>0.05). In a previous study by Zewdu (2005) the dry matter yield obtained was 34,570 kg ha^{-1} yr^{-1} and this lower yield could be due to the lower rainfall in Ethiopia compared to Malaysia (more than 2000 mm in Malaysia and 860-1771 mm in Ethiopia).

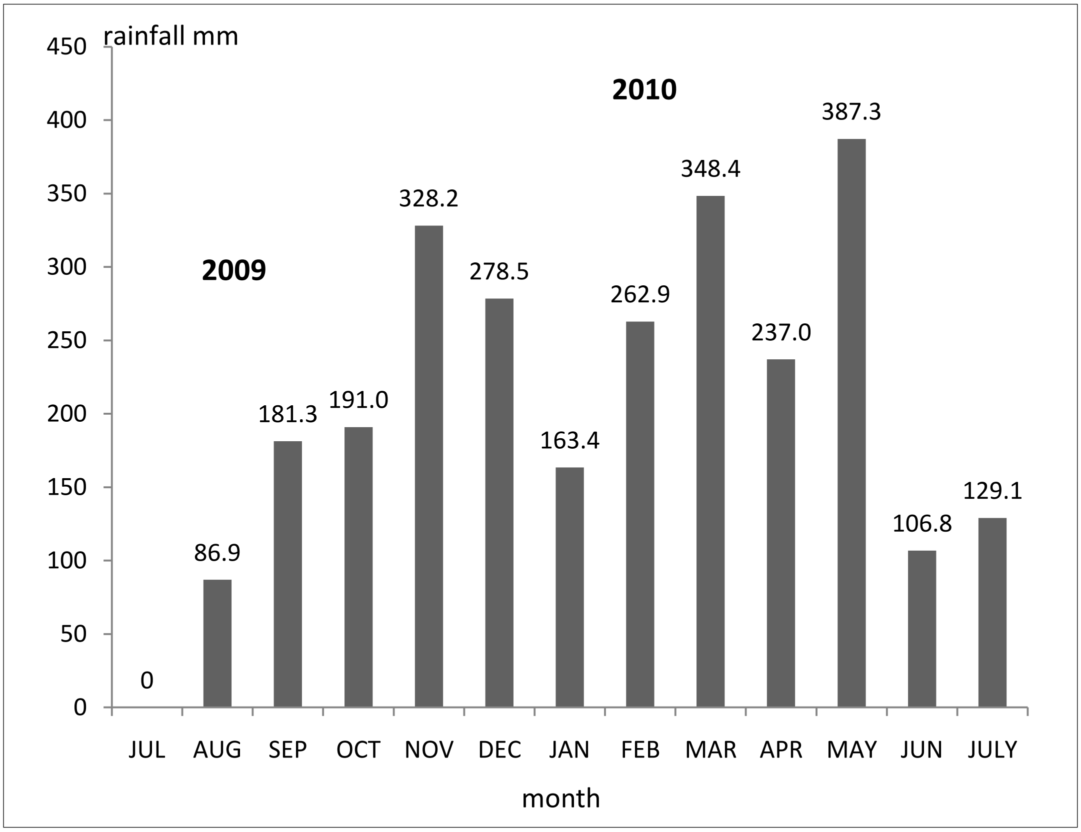

Figure 1: Monthly rainfall during experiment

There were significant differences among the nine varieties of Napier grass in their nutritive quality parameters (P<0.05) (Table 3). Mean NDF content over the five harvests were significantly different between varieties (P<0.05). However at harvest 6, there were no significant differences in NDF % among varieties probably due to the dry period and slower growth of all varieties. Generally the taller varieties had higher NDF and ADF than the shorter varieties (Table 4). Crude protein content was also higher in the shorter varieties compared to the taller varieties (Table 4). The highest crude protein content was obtained by Australian Dwarf variety with 12.08% while all the tall varieties showed crude protein content of less than 11%. In summary, the taller varieties tended to have higher dry matter yield compared to the shorter varieties but the latter were higher in nutritive value. There did not appear to be much difference among the six tall varieties of Napier either in terms of dry matter yield or nutritive quality except that Red Napier showed significantly lower NDF content compared to Uganda Napier. Among the short varieties, Australian Dwarf Napier showed significantly lower NDF values compared to Dwarf Napier. Dwarf Napier showed significantly greater LSR than the other two short varieties.

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Table 3: Mean squares from analysis of variance for nutritive quality for 9 varieties of Napier grass in 6 harvests

Source of variation	df	Crude protein (CP)	Neutral detergent fiber (NDF)	Acid detergent fiber (ADF)	Acid detergent lignin (ADL)
Block	4	10.41**	9.65**	1.63	3.02
Varieties	8	3.28**	14.15**	9.44**	2.87
Error	32	0.54	2.30	2.59	3.17
CV %		6.87	2.18	4.22	21.58

**significant at $p \leq 0.01$, *significant at $p \leq 0.05$

Table 4: Nutritive quality of nine Napier grass varieties

Variety	Crude Protein %	Neutral Detergent Fibre (NDF) %	Acid Detergent Fibre (ADF) %	Acid Detergent Lignin (ADL) %
King grass	10.11[c]	70.10[ab]	38.10[ab]	6.85[a]
Common Napier	9.79[c]	70.90[ab]	38.80[ab]	9.24[a]
Red Napier	10.36[c]	69.30[bc]	38.20[ab]	7.45[a]
Taiwan Napier	10.09[c]	70.00[ab]	39.90[a]	7.99[a]
Uganda	10.36[c]	71.80[a]	39.80[a]	8.22[a]
Indian Napier	10.64[bc]	70.00[ab]	38.80[ab]	8.65[a]
Dwarf Napier	11.5[6ab]	69.10[bc]	37.00[bc]	8.77[a]
Dwarf 'Mott'	11.61[ab]	67.80[cd]	36.90[bc]	8.96a
Australian Dwarf	12.08[a]	66.10[d]	35.70[c]	8.19[a]

[abcd] Means with common superscripts are not significantly different (P>0.05) using DMRT

Table 5: Correlation coefficients between agronomic and nutritive quality parameters measured in Napier grass varieties

	TIL	HT	DMY	NDF	ADF	ADL	CP
HT	-0.42**						
DMY	-0.06	0.27**					
NDF	0.03	-0.19*	0.12				
ADF	-0.36**	0.64**	0.41**	0.07			
ADL	0.22**	-0.16*	0.04	0.13	0.03		
CP	0.51**	-0.60**	-0.21**	0.30**	-0.50**		
LSR	0.31**	-0.62**	-0.31**	0.38**	-0.55**	0.08	0.68**

ADF = acid detergent fibre; ADL = acid detergent lignin; CP = crude protein; DMY = dry matter yield; HT = height; LSR = leaf to stem ratio; NDF = neutral detergent fibre; TIL = number of tillers
*Significant at $p<0.05$; **significant at $p<0.01$

A correlation analysis for all the parameters measured showed negative correlation coefficients between nutritive qualities with plant height, indicating that taller varieties were lower in nutritive quality compared with the short varieties (Table 5). These associations can be explained by the differences in LSR between varieties. Shorter varieties have higher LSR and the leafier swards make the whole-plant nutritive quality better than the tall varieties that are stemmier. The three parameters in the correlation analysis that were most closely associated with plant height were LSR (r= -0.62), CP (r= -0.60) and ADF (r= +0.64). On the other hand, dry matter yield was positively correlated with plant height (r=0.27) but the association was not as strong as that of the nutritive quality parameters. Plant height and number of tillers were negatively correlated (r= -0.42), thus the shorter varieties had more dense tillering than the taller ones.

From the correlation coefficients between agronomic and nutritive quality measured in Napier grass varieties, it can be summarized that taller varieties had higher dry matter yield but less tillering and were less leafy than shorter varieties. Tall varieties out yielded the shorter varieties but this was at the expense of nutritive quality.

Conclusion

The short Napier varieties were leafier and had higher nutritive quality than the tall varieties although the dry matter yield tended to be lower than the tall varieties. Among the short varieties there were little differences in dry matter yield or nutritive quality. Similarly, there were no significant differences between the six tall varieties in yield or nutritive quality. The short varieties had denser tillering compared to the tall varieties showing a difference in photosynthate partitioning between the two groups of Napier grass. Farmers can choose the tall varieties of Napier to obtain higher quantity of forage but when livestock has special needs for higher quality feed such as for dairy production then the shorter varieties will be a better choice.

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