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Short Communication

Growth characteristics, biomass yield and mineral concentrations in seven varieties of Napier grass (*Cenchrus purpureus*) at establishment in Kelantan, Malaysia

Características de crecimiento, producción de forraje y concentración mineral en la fase de establecimiento de siete variedades del pasto Napier (Cenchrus purpureus) *en Kelantan, Malasia*

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Abstract

Growth characteristics, biomass yield and mineral concentrations were evaluated in a completely randomized design study of 7 Napier grass varieties. Data on tiller number per plant, plant height, leaf length, leaf width, stem diameter, leaf:stem ratio and dry matter (DM) yield, as well as concentrations of nitrogen, calcium, magnesium, phosphorus, sodium, potassium, zinc, copper, manganese and iron, were obtained at 2 months growth. The growth characteristics, DM yields and mineral concentrations (except phosphorus) varied significantly ($P<0.01$) among varieties. The variety Indian was tallest (221 cm) and produced the highest DM yield (6.3 t/ha), whereas Dwarf had the highest tiller number and leaf:stem ratio. Purple had the longest and Taiwan and Indian the widest leaves. Kobe, Pakchong and Purple had the greatest stem diameter. Concentrations of Ca, K and Na were greatest in Zanzibar, while Dwarf had the highest concentrations of N, Zn, Mn and Fe. Studies beyond the establishment phase over a range of seasons and in a range of environments at different ages of harvest are needed to confirm the merits of different Napier grass varieties in the study zone.

Keywords: Dry matter yield, macro- and micro-minerals, plant height, tropical grasses.

Resumen

En Kelantan, Malasia se evaluaron las características de crecimiento, la producción de materia seca (MS) y las concentraciones minerales de 7 variedades del pasto Napier durante la fase de establecimiento. Dos meses después de loa siembra fueron determinados el número de brotes por planta, la altura de la planta, longitud de la hoja, ancho de la hoja, diámetro del tallo, rendimiento de MS y relación hoja:tallo, y se analizaron las concentraciones de nitrógeno, calcio, magnesio, fósforo, sodio, potasio, zinc, cobre, manganeso y hierro. Los parámetros de crecimiento, la producción de MS y las concentraciones minerales (con excepción del P) variaron significativamente ($P<0.01$) entre las variedades. La variedad Indian fue la más alta (221 cm) y produjo el mayor rendimiento de MS (6.3 t/ha), mientras que Dwarf tuvo el mayor número de brotes y la relación hoja:tallo más alta. Purple presentó las hojas más largas y Taiwan e Indian las más anchas. Kobe, Pakchong y Purple mostraron el mayor diámetro de tallo. Las concentraciones de Ca, K y Na fueron mayores en Zanzibar, mientras que Dwarf tuvo las mayores concentraciones de N, Zn, Mn y Fe. Se necesitan estudios más allá de la fase de establecimiento, durante un tiempo prolongado, con varias edades de corte y en diferentes condiciones ambientales para confirmar los méritos de las diferentes variedades del pasto Napier en la zona del estudio.

Palabras clave: Altura de planta, forraje, gramíneas tropicales, minerales macro y micro, producción de materia seca.

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Introduction

Ruminant livestock obtain their mineral requirements from concentrates and/or roughage sources, depending on the feeding circumstances. Intake of minerals in the diet must reach the recommended levels if livestock health, reproductive efficiency and performance are to be maintained at a satisfactory level (Ward and Lardy 2005). Obtaining mineral requirements from roughage sources is preferable, since roughage is usually less expensive than concentrates.

Different species of grasses have different capacities to absorb minerals from the soil. Napier grass is one of the most widely used forages for ruminants in developing countries, including Malaysia, because of its high biomass yield and ease of propagation (Halim et al. 2013). A number of varieties of Napier grass are cultivated, including Zanzibar, Indian, Kobe and Taiwan, and these different types vary in morphology, dry matter (DM) yield and nutritive value (Halim et al. 2013). However, little information has been published regarding the mineral composition of forage from various Napier grass varieties. Therefore, the objective of this study was to investigate the growth characteristics and mineral composition of 7 varieties of Napier grass, as a guide for subsequent studies.

Materials and Methods

Study site

This study was conducted at the Agro Techno Park, Universiti Malaysia Kelantan (UMK), Jeli campus (5°44.46′ N, 101°52.31′ E), Kelantan, Malaysia, from July to September 2018. Climatic conditions during the study and the past 9 years (2009–2018) are shown in Figure 1.

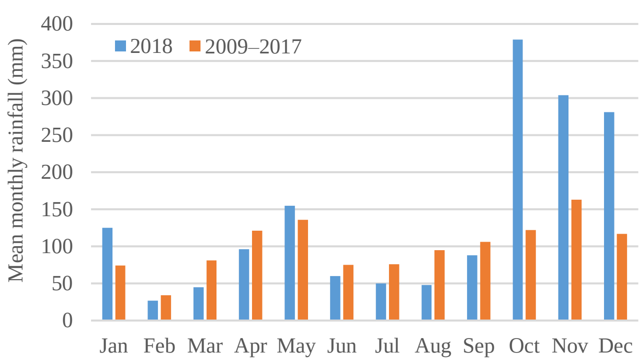

Figure 1. Monthly rainfall during 2018 and short-term mean rainfall (2009–2017) at the experimental station.

The soil was classified as a moderate reddish-brown lateritic soil with the following physical and chemical properties in the top 15 cm of soil as analyzed by conventional methods (Tan 2003): >20% clay; 25 mS/m electrical conductivity; 2.3% N; 4.6% organic matter; 2.7% organic carbon; and pH 5.3.

Experiment establishment

The area selected for planting was cleared and ploughed to provide a good tilth. Stem cuttings of 7 varieties of Napier grass (Taiwan, Zanzibar, Dwarf, Pakchong, Purple, Kobe and Indian) were purchased from a local supplier and planted in rows at spacings of 0.5 × 0.5 m by placing them horizontally in a furrow and covering with soil. Twenty-one plots were established in a completely randomized design to give 3 plots for each variety. The area of each plot was 2.5 × 2.5 m, and the plots were separated by 1.0 m paths.

Before planting, goat manure was applied to the land at a rate of 10 t/ha as a basal fertilizer. Each kilogram of goat manure contained 22.1 g nitrogen (N), 13.4 g phosphorus (P), 2.6 g potassium (K), 25.1 g calcium (Ca), 3.6 g magnesium (Mg), 1.1 g sodium (Na), 18.4 mg copper (Cu), 72.5 g zinc (Zn), 289 mg manganese (Mn) and 150 mg iron (Fe). Lime was also applied at a rate of 50 kg $Ca(OH)_2$/ha. An N:P:K fertilizer (15:15:15) was applied at the rate of 50 kg/ha during Napier grass establishment. Irrigations were applied as determined by weather conditions.

Growth parameters

After 60 days growth the following growth parameters were determined on 5 randomly selected plants per plot: plant height (PH; from the soil surface to the tip of the longest leaf); leaf length (LL); leaf width (LW); stem diameter (SD); and leaf:stem ratio (LSR). The number of plants and total tiller numbers (TN) of all plants were counted for each plot. Plants were harvested at about 10 cm above the ground. Leaf was considered to include leaf blade and leaf sheath. The harvested material was weighed to determine fresh weight, and a representative sample was taken for determination of total dry matter (DM) yield and LSR. For estimation of LSR, plant material was sorted into leaf and stem fractions. Whole plant, leaf and stem were chopped and dried in an oven for 48 hours at 70 °C for dry weight determination. Dried samples of chopped whole plant were ground and sieved through a 1 mm sieve for further chemical analyses.

Chemical analyses

Nitrogen concentration was determined by the Kjeldahl procedure (AOAC 2005) whereas mineral composition (Ca, P, Mg, K, Na, Cu, Zn, Mn and Fe) was determined as described by Cottenie (1980).

Statistical analysis

Data were analyzed by using one-way analysis of variance, and Duncan's Multiple Range Test was used to determine differences between treatment means at P<0.05.

Results and Discussion

Tiller numbers per plant and plant height

Tiller numbers per plant were higher (P<0.05) in the Dwarf variety (9.2 tillers) than in the other 6 (tall) varieties, with an overall mean of 3.6 tillers/plant (Table 1). In contrast with this study, Halim et al. (2013) observed 19.6 tillers per plant in the Dwarf variety compared with 14.8 tillers in tall varieties. This difference might reflect an effect of age and cutting frequency, because the results of the current study were obtained at the first cutting following planting. Similarly, PH differed (P<0.05) by variety, with Indian being the tallest (221 cm) and Dwarf being the shortest (77 cm). The average PH for the 6 taller varieties in the present study was 192 cm (range 158–221 cm), which contrasts with the average PH of 55.7 cm (range 41.6–69.8 cm) for 12 varieties in Kenya reported by Nyambati et al. (2010). These differences might reflect variations in soil fertility, management or environment in the experimental areas (Singh et al. 2013).

Leaf length, leaf width and stem diameter

The LL ranged from 51.5 to 93.0 cm and varied (P<0.05) depending on variety. The LL in this study was similar to that determined by Mdziniso (2012), who reported a range of LLs for Napier grass of 30–120 cm. Similarly, LW varied (P<0.01) among the varieties, with the lowest value measured for Kobe (1.8 cm) and the highest value for both Taiwan and Indian (2.5 cm) (Table 1). The measurements of LW in the present study also agree with the findings of Mdziniso (2012), who reported a range of LWs for Napier grass of 1.0–5.0 cm. Stem diameter also varied (P<0.05) among the varieties, with the lowest value (5.4 cm) for Dwarf and the highest value (6.8 cm) for Kobe, Pakchong and Purple. Nyambati et al. (2010) found that the SDs of 12 Napier grass varieties ranged from 4.0 to 6.8 cm, which was greater than the range in our study. These differences in LL, LW and SD could differ among the varieties due to genetics, as well as other factors like soil fertility and climatic conditions (Singh et al. 2013).

Biomass yield

Dry matter yield at 60 days growth differed (P<0.05) among the varieties, with the lowest yields for Kobe (1.6 t DM/ha) and Dwarf (2.0 t DM/ha) and the highest yield (6.3 t DM/ha) for Indian. These DM yields were much lower than those reported in a previous study (Turano et al. 2016) and could be attributed to the lower rainfall experienced early in the Napier grass establishment period. As expected, in the present study, the Dwarf variety showed a LSR of 3.0 (P<0.05), higher than those of the tall varieties, which ranged from 0.7 to 1.8 (Table 1). Halim et al. (2013) also found the highest LSR in the Dwarf variety.

Table 1. Growth characteristics and dry matter yields for Napier grass varieties.

Parameter[1]	Variety (Mean ± standard deviation)							Overall
	Taiwan	Zanzibar	Kobe	Pakchong	Purple	Indian	Dwarf	
TN/plant	2.5a[2] ±0.4	3.1a ±0.6	3.2a ±0.2	2.2a ±0.8	2.4a ±0.4	2.9a ±0.3	9.2b ±1.0	3.6 ±2.4
PH (cm)	202d ±16.6	172bc ±9.4	158b ±14.1	195cd ±12.3	203d ±28.4	221d ±17.3	77a ±3.2	175 ±47.5
LL (cm)	88.2cd ±2.6	80.4b ±5.1	79.3b ±3.3	83.3bc ±4.9	93.0d ±6.9	86.8bcd ±4.7	51.5a ±1.0	80.4 ±13.4
LW (cm)	2.5c ±0.2	1.9a ±0.3	1.8a ±0.2	2.3bc ±0.2	2.0ab ±0.2	2.5c ±0.3	2.0ab ±0.1	2.1 ±0.3
SD (cm)	6.5bc ±0.3	6.2b ±0.5	6.8c ±0.1	6.8c ±0.5	6.8c ±0.4	6.7c ±0.2	5.4a ±0.1	6.5 ±0.5
LSR	1.0a ±0.2	1.8a ±1.9	0.7a ±0.1	0.7a ±0.1	0.8a ±0.1	0.7a ±0.2	3.0b ±0.4	1.2 ±1.0
Mean DM yield (t/ha)	3.6ab ±1.5	2.6ab ±1.0	1.6a ±0.2	4.7bc ±1.9	4.2abc ±2.0	6.3c ±1.8	2.0ab ±0.2	3.6 ±2.0

[1]TN – tiller number; PH – plant height; LL – leaf length; LW – leaf width; SD – stem diameter; LSR – leaf:stem ratio.
[2]Means within rows followed by different letters are different at P<0.05.

Macro-mineral concentrations in plants

Concentrations of N, Ca, Mg, K and Na in plants varied (P<0.05) among varieties (Table 2), while P concentration did not differ (P>0.05), with an overall mean of 4.8 g P/kg DM. The variation in mineral composition among different varieties suggests that an opportunity exists for cultivation or selection of a suitable variety if the objective is to obtain high levels of dietary minerals from the plants.

Dwarf variety contained higher (P<0.05) N than other varieties. Even Taiwan and Indian varieties, which showed the lowest N concentrations in forage, would provide almost sufficient N for effective functioning of the rumen and for maintenance of growing ruminants if fed as cut-and-carry forage, while the Dwarf variety was well above the maintenance level. Supplementing with N in the form of non-protein-nitrogen, e.g. urea, could increase intake. Where animals were allowed to select from available forage, sufficient N to support weight gains would be obtained.

The Ca concentration in the present study ranged from 2.54 to 6.50 g/kg DM, whereas the recommended Ca requirement for ruminants is 3 g/kg DM (Table 2). Hence, all varieties, apart from Purple and Indian, in this study contained sufficient amounts of Ca to provide adequate dietary Ca for ruminants. The present data showed that P concentrations in Napier grass ranged from 4.1 to 5.6 g/kg DM, with no differences among the varieties, which would supply the normal requirements for ruminants (2.5 g/kg DM) (Table 2).

The differences in K concentration found between the 7 varieties (range 20.2 to 40.4 g/kg DM) were in line with those documented by Turano et al. (2016), who reported a range of K concentrations in forages from 21.5 to 39.1 g/kg DM. These values are higher than the recommended K concentration (6–8 g/kg DM) for ruminants (Table 2). The Mg concentration in forages for ruminants should be 2.0 g/kg DM, as recommended by McDowell and Arthington (2005), but this value is higher than the Mg concentration of the Napier grass varieties studied in the present work. Therefore, all the studied Napier grass varieties need to be fortified with Mg to eliminate Mg deficiency, if these varieties are to be used as the sole feed for ruminants. Most of the Napier grass varieties in this study contained adequate amounts of Na for ruminants (Table 2), but Pakchong, Purple and Indian were deficient in Na.

Micro-mineral concentrations in plants

Table 3 shows that the Dwarf variety contained higher (P<0.05) concentrations of Zn than Pakchong and Purple. Kobe contained higher (P<0.05) concentrations of Cu than all other varieties, except for Zanzibar. The data presented in this study suggest a deficiency in the levels of Cu and Zn for ruminants fed Napier grass. All varieties showed levels of Zn slightly lower than those required by ruminants. Similarly, most of the studied Napier grass varieties showed levels of Cu (except for Zanzibar, Kobe and Dwarf varieties) slightly lower than those required (Table 3).

Concentrations of Mn were higher (P<0.05) in Dwarf than in all other varieties. Similarly, the Dwarf variety contained higher (P<0.05) concentrations of Fe than all other varieties. By contrast, Fe and Mn concentrations in this study were at levels considered adequate to excessive in all 7 Napier grass varieties (Table 3).

Table 2. Macro-mineral concentrations (g/kg DM) in Napier grass varieties.

Mineral	Variety (Mean ± SD)							Overall	Critical level (g/kg DM)
	Taiwan	Zanzibar	Kobe	Pakchong	Purple	Indian	Dwarf		
N	10.9a	11.4a	12.1a	11.1a	11.7a	10.3a	19.7b	12.5	16.6[2]
	± 0.6	± 1.4	± 1.1	± 2.1	± 1.6	± 1.2	± 1.5	±3.3	
Ca	3.6ab[1]	6.5c	4.5abc	3.0a	2.5a	2.9a	5.6abc	4.1	3.0[3]
	±1.6	±1.3	±1.08	±0.48	±0.20	±0.73	±1.60	±1.7	
Mg	1.4abc	1.4abc	1.2ab	1.3abc	1.0a	1.5bc	1.6c	1.3	2.0[3]
	±0.2	±0.1	±0.21	±0.21	±0.35	±0.22	±0.19	±0.3	
K	33.0bc	40.4c	36.4bc	20.2a	26.2ab	28.8ab	36.3bc	31.6	6.0–8.0[3]
	±5.7	±5.9	±6.10	±7.17	±7.40	±2.25	±1.81	±8.1	
Na	0.6a	2.2b	1.0ab	0.3a	0.2a	0.3a	0.6a	0.8	0.6[3]
	±0.8	±0.4	±1.32	±0.13	±0.02	±0.16	±0.86	±0.8	
P	5.6	5.1	5.4	4.1	4.4	4.1	4.7	4.8	2.5[3]
	±0.7	±2.1	±0.5	±1.4	±1.0	±1.2	±0.4	±1.2	

[1]Means within rows followed by different letters differ at P<0.05. [2]Critical level based on lactating cow needs (McDonald et al. 2011). [3]Critical level based on growing animal (ruminant) needs (McDowell and Arthington 2005).

Table 3. Micro-mineral concentrations (mg/kg DM) in Napier grass varieties.

Mineral	Variety (Mean ± SD)							Overall	Critical level (mg/kg DM)[2]
	Taiwan	Zanzibar	Kobe	Pakchong	Purple	Indian	Dwarf		
Zn	25.4ab[1] ±1.4	23.1ab ±2.0	23.6ab ±3.1	21.5a ±3.1	21.7a ±5.7	26.4ab ±1.9	28.8b ±4.7	24.4 ±3.8	30
Cu	8.2a ±0.5	11.3bc ±1.1	12.2c ±0.3	8.5a ±0.6	9.1a ±1.0	8.9a ±1.4	10.0ab ±1.4	9.7 ±1.7	10
Mn	76.7a ±7.4	79.6a ±13.0	93.1a ±10.0	71.2a ±6.0	81.8a ±4.0	78.0a ±29.8	157.4b ±41.8	91.1 ±33.3	30–40
Fe	114a ±12.1	116a ±3.3	139a ±27.5	87a ±11.3	120a ±7.9	134a ±24.5	241b ±87.3	136 ±55.8	30

[1]Means within rows followed by different letters differ at P<0.05. [2]Critical level based on growing animal (ruminant) needs (McDowell and Arthington 2005).

Conclusion

The results presented here indicate that Indian, Purple and Pakchong varieties may be better suited to the study area than the other tested varieties by virtue of better PH, LL, LW, SD and DM yield at establishment. Conversely, Dwarf variety showed better TN per plant and LSRs than the other varieties. Zanzibar variety could provide an adequate amount of macro-minerals, such as N, Ca, K and Na, while the Dwarf variety could provide an adequate amount of micro-minerals, such as Zn, Mn and Fe. However, the amount of Mg in all 7 Napier grass varieties may not be sufficient to meet the dietary requirements of ruminants.

Since the information provided here refers to an establishment phase of only 60 days, it should be considered preliminary. However, it is a useful basis for subsequent production phase studies at different stages of harvest and with different growth/cutting cycles with the final objective to allow farmers to choose the most suitable varieties of Napier grass based on their special needs to obtain higher quantity or higher quality of forage.

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(Note of the editors: All hyperlinks were verified 20 November 2019.)

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